# THE EMBRYO-SAC OF *ELÆIS GUINEENSIS* JACQ.—A REINVESTIGATION

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*Elæis guineensis* Jacq., the African Oil Palm, is well known as the source of palm oil. A few plants of this species were planted in the Law College Gardens, Poona, mainly for ornamental purpose. These plants are now 10–12 years old and produce fruits whose pericarp and endosperm contain the normal quantity of oil.

Recently De Poerck (1950) studied the development of embryo-sac in this species. He reported that the megaspore mother cell develops directly into the eight-nucleate embryo-sac without forming the megaspore tetrad. According to De Poerck, therefore, the development of the embryo-sac in *Elæis guineensis* corresponds to the *Adoxa* type. Quisumbing and Juliano (1927) have also reported the *Adoxa* type of embryo-sac in *Cocos nucifera*, although the presence of degenerating megaspores in this species was previously reported by Bauch (1911). A modified *Adoxa* type of embryo-sac, with 5 nuclei (4 micropylar+1 chalazal), is reported by Gioelli (1930) in *Chamærops humilis*. All these observations are of a doubtful character and a reinvestigation of these plants is very desirable.

The authors (Kajale and Ranade, 1952) have already demonstrated the formation of megaspores in *Elæis guineensis*. A detailed account of the investigation is given in the present paper.

The material was collected exclusively from the plants growing in the grounds of the Law College, Poona. The female flowers were dissected out carefully from the inflorescences and then fixed in formalin-acetic-alcohol and Navaschin's fluid. Customary methods were employed for dehydration and embedding. Sections were cut 10–20$\mu$ thick. They were stained in Heidenhain's hæmatoxylin and destained in a saturated solution of picric acid.

## THE OVULE

The ovule is crassinucellate and bitegmic (Fig. 1). It is sessile, orthotropous, though slightly inclined towards one side. The inner

FIGS. 1–13

FIGS. 1–13. *Elæis guineensis.*—Figs. 1 and 2. L.S. of ovules at megaspore mother cell and mature embryo-sac stages respectively. Note the presence of a prominent bulge in the mature embryo-sac in Fig. 2. Fig. 3. L.S. of nucellus showing megaspore mother cell and parietal cells. Fig. 4. Dyad cells. Fig. 5. L.S. of nucellus showing T-shaped tetrad and parietal tissue. Figs. 6–8. Linear, T-shaped and isobilateral tetrads. Fig. 9. A tetrad showing the enlargement and degeneration of the third megaspore. Fig. 10. 4–Nucleate embryo-sac. Fig. 11. The chalazal end of an embryo-sac showing three degenerating antipodals. Fig. 12. The micropylar part of an embryo-sac showing two synergids and the secondary nucleus. Note the developing haustoria. Fig. 13. The egg from the same embryo-sac as shown in Fig. 12. Figs. 1 and 2, × 75; the rest, × 750.

integument consists of 5–7 layers of cells. It grows faster than the outer integument and covers the nucellus at the megaspore mother cell stage to form the endostome, which soon closes as the integument develops into a short solid beak protruding into the exostome formed by the outer integument. The cells in the region of the beak become filled with tannin before the embryo-sac matures. The fertilization stages of the ovule have not been studied during the present investigation, but in view of the early closure of the endostome and the deposition of the tannin in its apical part, it should be of interest to observe the course of the pollen tube in the ovule.

The outer integument is much more massive than the inner one. It forms the exostome at about the time when the megaspore tetrad is formed. The endostome, being closed, the micropyle proper is formed by the exostome only. Unlike the endostome the exostome remains open (Fig. 2). The outer integument is supplied by a ring of 15–18 vascular bundles which extend to about two-thirds of its length. The top of the outer integument is characterized by a shallow depression. In the centre of this is the opening of the micropyle (Fig. 2).

### MEGASPOROGENESIS

In order to secure the early stages of megasporogenesis it is necessary to cut crowns of leaves from some plants, since the inflorescences at this time are not externally visible and are placed deep in the axil of strong leaf bases. As the plants at Poona are limited in number and are grown for ornament the leaves could not be cut. Therefore, the earliest stages of megasporogenesis have not been studied by us. De Poerck (1950), however, says that there are 1 or 2 megaspore mother cells in an ovule out of which one develops into the embryo-sac. The earliest stage observed by us during megasporogenesis is shown in Fig. 3. It shows a single megaspore mother cell and 2 parietal cells, indicating that the archesporium is hypodermal in origin. The parietal cell divides anticlinally and periclinally to form a parietal tissue of 2 layers of cells. Sometimes 3 layers may also be seen. This tissue does not persist for long and along with the cells of the nucellus it begins to degenerate during the early stages of embryo-sac development. Only the epidermal layer of the nucellus is visible at the mature embryo-sac stage.

Contrary to what is reported by De Poerck (1950) the formation of tetrads of megaspores is a regular feature in the development of
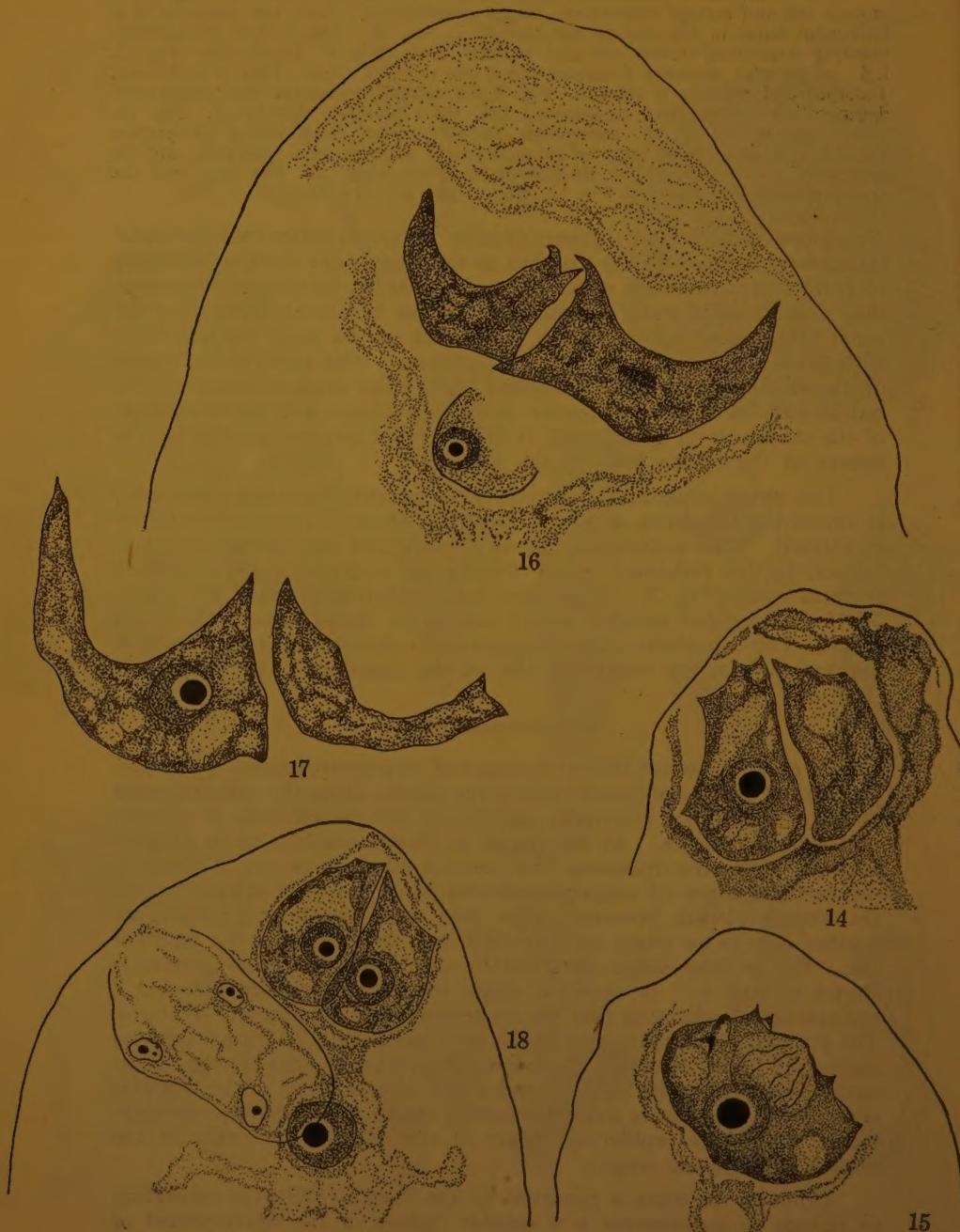
FIGS. 14–18

ovule in *Elæis guineensis.* The form of the tetrads, however, varies greatly and as many as four different kinds of arrangements have been observed. As previously reported by us (Kajale and Ranade, 1952), the megaspore mother cell divides transversely and forms a dyad of 2 cells (Fig. 4). The next division in each of these dyad cells, however, occurs in different planes resulting in 4 kinds of tetrads. A linear tetrad is formed if both the dyad cells divide transversely (Fig. 6). Most often the micropylar dyad divides in a plane at right angles to that of chalazal one and forms a T-shaped tetrad (Figs. 5 and 7). A case of an inverted T-shaped tetrad was also met with. In a few instances it was observed that the dyad cells divided in a plane parallel to the long axis of the ovule resulting in an isobilateral arrangement of the megaspores (Fig. 8).

The chalazal megaspore develops in a normal manner into the 8-nucleate embryo-sac. The remaining 3 megaspores degenerate (Fig. 7). In one case, however, the third megaspore of the tetrad showed signs of enlargement, but it was degenerating like the other two micropylar megaspores (Fig. 9). The chalazal megaspore, though smaller in size, was in healthy condition and appeared to be functioning.

### EMBRYO-SAC

After the 4-nucleate stage the embryo-sac increases considerably in size. The mature embryo-sac has a tapering chalazal end (Fig. 2). There is a slight bulging on one side of the embryo-sac just where the tapering begins (Fig. 2). The antipodals are 3 in number, are short-lived and occupy the tip of the embryo-sac (Fig. 11). The secondary nucleus is situated in the micropylar half and is comparatively big. Starch grains may appear at this stage, but usually they appear a little later.

The egg apparatus exhibits a variety of forms. It consists of an egg and 2 synergids. The former may be roughly flask-shaped with a broad neck or may be bell-shaped (Fig. 13). It has the usual micropylar vacuole and a basal nucleus. It is much smaller than the synergids and also stains more faintly than the latter.

The synergids, on the other hand, present several interesting and noteworthy features. At first they are pear-shaped in appearance, have a vacuole at the base and a nucleus towards the micropylar end; but soon they become considerably enlarged and their cytoplasm begins to stain deeply. The most remarkable feature about their structure is the presence of several short and pointed projections which develop mostly on the micropylar half (Fig. 14). Occasionally such projections may be found on the lower half of the synergids also (Fig. 14).

These projections may be described as hooks. Two to four of them or even more may be counted on a single synergid. In having multiple hooks the synergids of *Elæis guineensis* differ markedly from other angiosperms, in most of which the synergids are characterized by the presence of a single hook only.

Another interesting point about the synergids is the development of haustoria. The first haustorium develops as a lateral tapering projection near the base of a synergid (Fig. 12; see the synergid on the left). Since the synergids persist for sometime during the post-fertilization stages the haustorium continues to develop and later forms a conspicuous structure with a broad base and a tapering end, the latter being directed towards the micropyle (Figs. 16 and 17). The development of the haustoria imparts a crescent-shaped appearance to the synergids in section. A similar but much smaller haustorium is also developed on the corresponding opposite side of the synergid (Figs. 12 and 16). The synergid haustoria are rather uncommon in angiosperms being known only in a few cases, such as *Ursinea* and *Calendula* (Dahlgren, 1924). In these plants the haustorium develops from the micropylar end of the synergid. *Elæis* differs from them in that the haustoria develop laterally from the synergids. The development of such lateral haustoria from the synergids is previously unknown in the angiosperms and is being recorded for the first time. The length of the synergid haustoria, however, is not very great. They were found in no case to grow beyond the limits of the embryo-sac.

It is interesting to note that a majority of the hooks disappear during growth of the haustoria presumably because they are mechanically stretched during this time. One or two hooks may, however, still be seen at the apical end of the synergid (Fig. 16). The position of the nucleus in the synergids also varies, but it is usually located in the centre. The synergids are rich in cytoplasm and may or may not show the presence of vacuoles (Figs. 16 and 17).

The structure of the synergids is further interesting in that they sometimes become egg-like. Such synergids also increase in size. The nucleus shifts to the base, the vacuole in this part disappears and instead a prominent micropylar vacuole develops. In addition to the micropylar vacuole, generally two more vacuoles, one on each side of the nucleus, also become prominent (Fig. 15). The micropylar vacuole is usually top-shaped with its apex directed upwards and has a number of striations in it converging towards its apical end. This is the filiform apparatus (Fig. 15). While becoming egg-like the synergids change their shape and become somewhat cup-shaped due to more active circumferential growth of the micropylar half. Egg-like synergids are also characterized by the presence of multiple hooks (Fig. 15).

A case of twin embryo-sacs was observed. This is shown in Fig. 18. One of the embryo-sacs had the normal size and structure, but the other one was much smaller and had only 3 nuclei. The smaller embryo-sac was observed in the vicinity of the egg apparatus of the normal embryo-sac.

## SUMMARY

A reinvestigation of the embryo-sac of *Elæis guineensis* has revealed that its development corresponds to the normal type.

The ovule is sessile, orthotropous, crassinucellate and bitegmic. The inner integument closes over the nucellus, before the embryo-sac matures, to form a solid beak in which tannin is deposited. The vascular bundles extend into the outer integument of the ovule up to about two-thirds of its length.

The tetrads of megaspores show 4 kinds of arrangements.

The synergids persist for sometime and become considerably enlarged. They are characterized by the presence of multiple hooks and develop lateral haustoria. Egg-like synergids are also fairly common.

The antipodals are three in number and are ephemeral.

A case of twin embryo-sacs has been noted.

## LITERATURE CITED

BAUCH, K. 1911. Beiträge zur Entwicklungsgeschichte und physiologischen Anatomie der Palmenblüte. Berlin.

DAHLGREN, K. V. O. 1924. Studien über die Endospermbildung der Kompositen. Svensk. Bot. Tidskr. 18 : 177–203.

DE POERCK, R. A. 1950. Contributions a l'étude du Palmier a huile Africain (*Elæis guineensis* Jacq.). Oléagineux. 5 : 623–28.

GIOELLI, F. 1930. II gametofito femmineo e l'evoluzione dell'ovulo in seme in *Chamærops humilis* L. Lav. Ist bot. Palermo. I : 24.

KAJALE, L. B. AND RANADE, S. G. 1952. Occurrence of four kinds of tetrads in *Elæis guineensis* Jacq. Curr. Sci. 21 : 170.

QUISUMBING, E. AND JULIANO, J. B. 1927. Development of ovule and embryo-sac of *Cocos nucifera*. Bot. Gaz. 84 : 279–93.

# A CONTRIBUTION TO THE ANATOMY AND MORPHOLOGY OF NORMAL AND SOME ABNORMAL FLOWERS OF *GYNANDROPSIS GYNANDRA* (L.) BRIQ.

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## INTRODUCTION

LIKE all other Rhœadalean families Capparidaceæ also has attracted considerable attention from floral morphologists during the last one hundred years or so. The present author got interested in *Gynandropsis gynandra* (*G. pentaphylla* DC.) through a cursory examination of some class-room material which showed numerous variations from the normal type. Raghavan (1939) has studied this species in detail but his conclusions have already been questioned (Puri, 1950), and the preliminary observations of the present author lent little support for what Raghavan asserts about the number of carpels and the placentæ. This state of affairs induced the author to re-investigate this species in greater details.

## MATERIAL AND METHODS

Normal and abnormal flower buds in different stages of development were collected at Meerut and fixed in F.A.A. Serial microtome sections, 10–15 microns thick, were cut and stained with crystal violet and erythrosin. In addition to *Gynandropsis*, prepared slides of *Cratæva religiosa, Capparis aphylla* and *C. horrida,* which were kindly lent by Dr. V. Puri, were also examined for comparison.

## OBSERVATIONS

*Vascular Anatomy of the Flower.*—The external morphology of the flower has already been described by Raghavan (1939). From the dissected siphonostele of the inflorescence axis a single trace passes out for each bract (Figs. 1 and 2). Very soon after its departure from the stele it divides first into three (Fig. 3), and then into five branches which are arranged in the form of an arc in transverse section. These five bundles fuse together before entering the base of the bract (Fig. 4). Within the bract this fusion product again divides into three branches (Fig. 5) each forming the midrib of a lobe which is conduplicately folded in the young condition (Fig. 6). Stoudt (1941) has reported two bract bundles arising successively from the same gap in *Cleome spinosa* but in *Polanisia trachysperma* and *P. graveolens* which also belong to Cleomoideæ, he describes a single trace which passes out directly into the bract. Just after the detachment of the bract, two small structures appear laterally on the pedicel in the position formerly occupied by the margins of the bract. They do not possess any vascular tissue
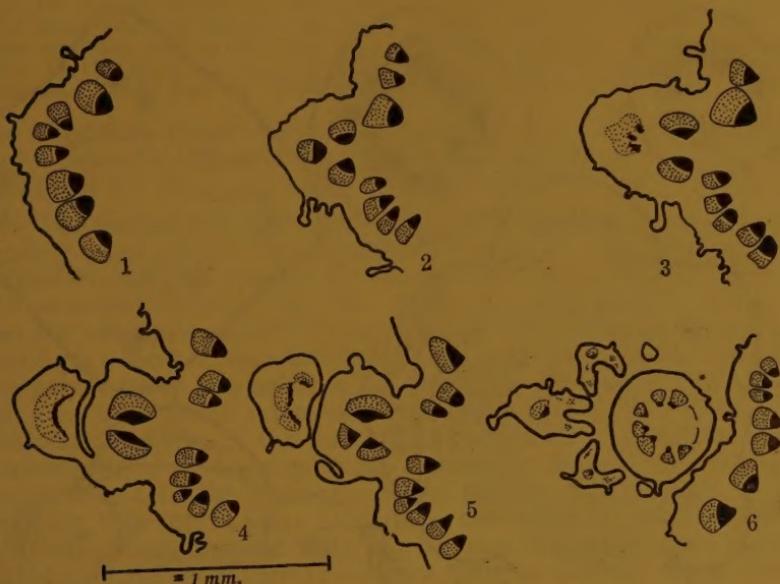
FIGS. 1–6. Successive transverse sections through a young inflorescence axis showing differentiation of bract, stipules, pedicel and their vascular supply. Figs. 1–2. Show one bract and two pedicel bundles diverging out. Fig. 3. Bract bundle divides. Figs. 4–6. Note the separation of stipules on either side of bract.

and disappear soon. These are regarded as the stipules of the bract (Figs. 4–6).

From the gap of the bract trace two more traces depart for the pedicel of the flower arising in the axil of the bract. They divide and redivide and form a dissected siphonostele of 8–12 collateral, endarch, unequal bundles (Fig. 7). In *Cleome spinosa* also (Stoudt, 1941) the pedicel receives two traces from the sides of the gap formed by the passing out of the bract trace. Higher up in the pedicel and just below the region of sepals the bundles increase somewhat in number.

There are four sepals occurring in two whorls of two each. The lateral sepals are the first to be marked off and also to receive their vascular supply (Figs. 8–11). But in older buds the lateral sepals finally become enwrapped by the median ones which thus come to appear outermost (Fig. 17). In some cases, however, the lateral sepals retain their original outer position (Fig. 16). Raghavan (1939) on the other hand reports that it is the median sepals which receive their vascular supply and separate off earlier than the lateral ones. Sepals and petals receive a single trace each which later on branches into three and finally into many corresponding to the ribs on their surface (Fig. 16).

Staminal traces separate from the stele in the upper half of the androgynophore. Every stamen receives a single trace (Figs. 12–15),
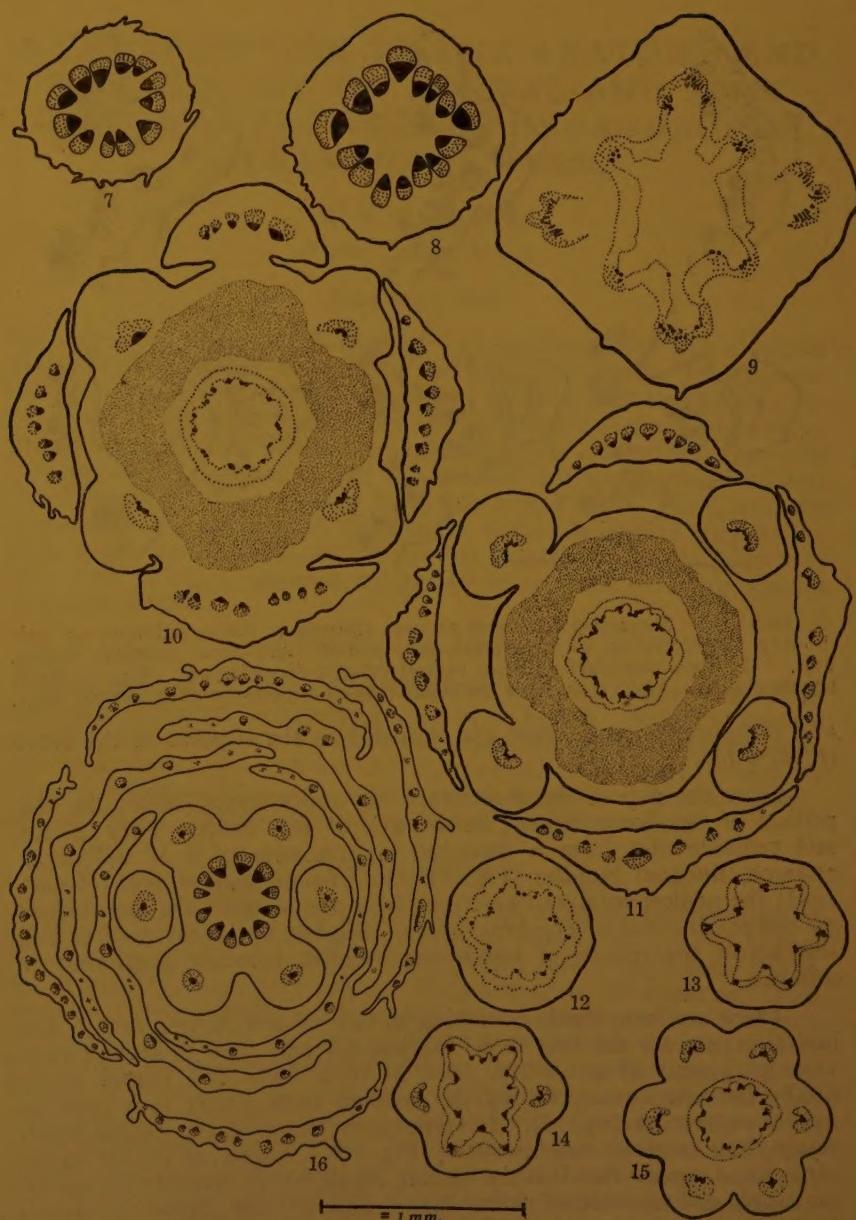
FIGS. 7–16. Serial cross-sections of a bud from pedicel upwards showing vascular supply to sepals, petals and stamens. Fig. 7. Transverse section of pedicel. Fig. 8. Vascular supply to lateral sepals passing out. Fig. 9. Bundles to sepals and petals are being marked off. Strands to the lateral sepals have reached the cortex while those of the median ones have not yet separated off.

Fig. 10.   Lateral sepals are completely detached from the receptacle.   Gaps left after sepal and petal supplies are being bridged.   Fig. 11.   All the sepals and some petals are marked off from the receptacle.   Note the nectariferous tissue. Figs.   12–15.   Show the staminal supply separating from the upper portion of the androgynophore.   Fig. 16.   Posterior sepal is enclosed by the laterals.

but Raghavan (1939) reports a "primary supply of three strands". In the base of the filament this bundle becomes concentric and traverses undivided for the entire length of the filament and the connective.

The central stele had hardly bridged its staminal gaps when it is again broken up into two prominent groups of vascular tissue, the secondary marginal bundles by the passing out of two lateral traces, the carpellary dorsals (Fig. 18).   From the sides of these groups of bundles small procambial strands proceed inward from opposite sides and form a band of vascular tissue on the inner side of the corresponding parent group of bundles in the anteroposterior plane (Figs. 19 and 20).   In these bands xylem elements differentiate on the outside, *i.e.*, towards the xylem of the outer bundles (Fig. 21).   Usually they are separated from the anteroposterior bundles by intervening parenchyma but in some cases the xylem elements of the two bundles come so close together that they appear to form a concentric bundle.   Raghavan (1939), however, does not make any mention of these inverted bundles, whatsoever.   Stoudt (1941) interprets them as ventrals of his "fertile carpel", while Puri (1945) describes them as placental bundles.

The two placentæ are median each consisting of two halves which are separated from one another by a strip of sterile tissue projecting inward (Fig. 21).   Each placenta bears four rows of ovules, the two on each half being oriented in opposite directions (Fig. 21).   Ovules receive the vascular supply generally from the sides of the inverted bundles.   In the upper regions of the ovary the strip of sterile tissue becomes somewhat grooved and is lined by loose, deep staining tissue (Fig. 22).   In this region the inverted bundles either disappear completely or merge with the antero-posterior ones forming a concentric bundle (Fig. 22).   The single bundle thus formed, splits into two which reach the stigma (Fig. 23).   The sterile strips become flatttened and meet in the centre dividing the loculus into two parts (Fig. 23). Fig. 24 shows the sequence of the finishing up of the "locules" one after another; the last to appear disappearing first.   The bundles in the placental region diverge out and fuse with the corresponding bundles from the other side in the region of the midrib (Figs. 24 and 25).   The number of xylem elements increase considerably before disappearing in the stigma. The stigmas, therefore, receive their vascular supply from the septal strands and not from the carpellary dorsals, though they are situated in the positions of the dorsals.

*Abnormal flowers.*—When plants were examined in the open field numerous abnormalities were encountered in the structure of the flower.   Some of the more interesting ones are referred to below (Figs. 26–40).

*Staminate flowers.*—In practically every inflorescence there were observed certain flowers which were functionally only male, as the

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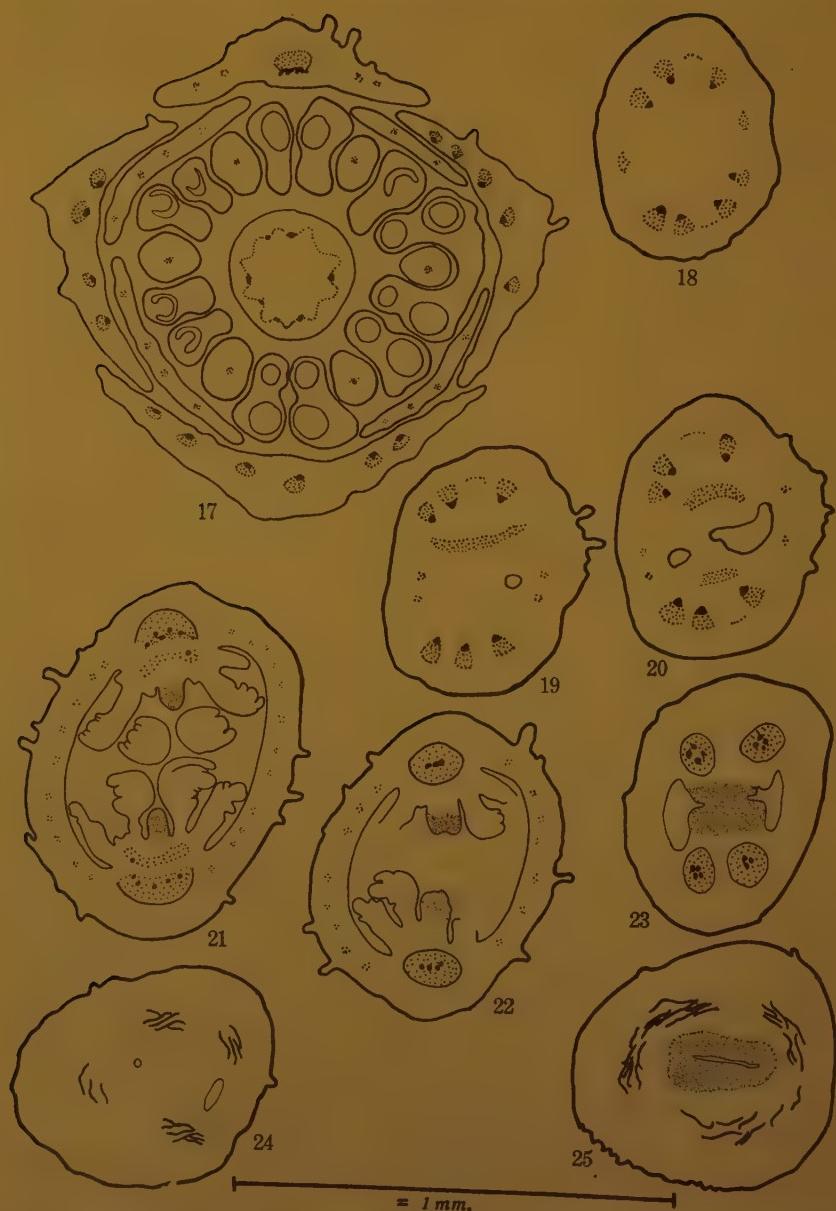
FIGS. 17–25. Fig. 17. Transverse section of a flower bud showing arrangement of lateral and median sepals. Note the gynophore in the centre. Figs. 18–25. Cross-sections of a bicarpellary ovary from base to stigma. Fig. 18. Shows carpellary dorsals diverging out. Fig. 19. Showing procambial strands and ovarian cavity appearing earlier on one side. Fig. 20. Ovarian cavity on the other

side is visible.    Fig. 21. The two placentæ are marked off and the ovules are oriented differently on the two sides.  Prominent secondary marginals and inverted placental bundles are clear.  Note also the sterile regions separating the two halves of each placenta.  Fig. 22. A single concentric bundle at each placenta. Groove has appeared in the sterile protuberance.    Fig. 23. Each concentric bundle is divided into two.  Figs. 24–25.  The branches of the concentric bundle are moving to their final positions in the midrib regions.

small sessile ovary was always found to be sterile (Fig. 26).   In some of these sepals, petals and stamens, are normally developed but in the others while sepals and petals are normal, the filaments may become so short, that the anthers appear to be subsessile.   The ovary is almost transparent and contains some abortive ovules which seldom differentiate completely.   It shrivels up very early and finally drops down. Raghavan (1939) who has also drawn attention to such flowers considers the condition as specific, for this species as it has not been reported so far in any other species of the genus.   The vascular supply of sepals, petals and stamens of such sterile flowers is quite normal; that of the ovary, however, is correspondingly reduced.

Other abnormalities observed concern to the number and position of the floral parts.   The author has not come across with any previous record in this species of such abnormalities.   In some flowers there may be five instead of four sepals.   The extra sepal in such cases may either result as a splitting of one of the four sepals (Fig. 27), or it may arise independently from the receptacle.   An extra petal may also arise in the same way, when fission of a petal takes place. It may affect the blade only or may extend even to the base of the claw.

One or more petals of a flower may show fission (Figs. 27 and 28).   In one flower five sepals and five petals arising independently were observed.

Adnation of some petals to the androgynophore and of stamens to the gynophore and ovary is also seen.   The adnated parts may be normal or show variations in the length of the claw, filament and partial staminody, etc., making it difficult to clearly demarcate the androgynophore and gynophore (Figs. 29–31).

Rarely cases of partial petalody of sepals, partial sepalody of petals and partial or complete staminody of petals are observed (see Figs. 28, 31, 36 and 37).

In one case partial pistillody of the lower portion of one of the anther lobes has been observed (Figs. 38 and 39). The ovary is unilocular and open with ovules of normal appearance attached to the slightly incurved margins. The portion of the anthersac enclosed in the ovary cavity also bears indistinct and polliniferous ovules on its wall (Fig. 40).   Such abnormal anthers may develop normal pollengrains.

An extremely interesting case of abnormality has also been observed where a tetracarpellary fruit when microtomed showed three accessory incompletely developed flowers inside appearing at different levels.   The vascular tissue was very well developed in the gynophore of this fruit.
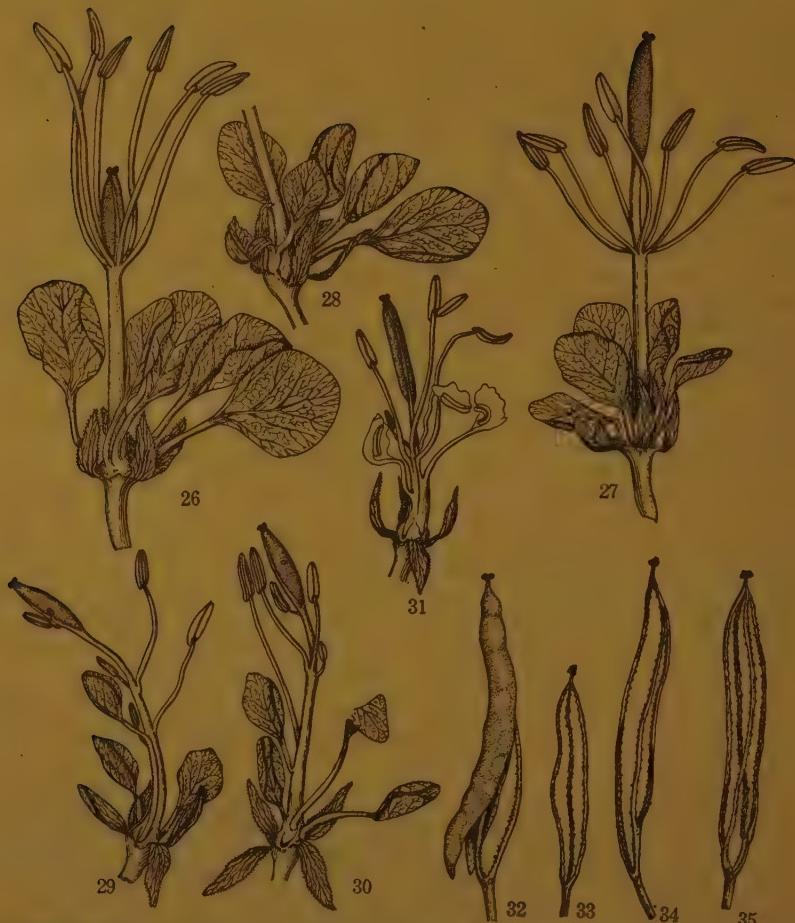
Figs. 26–31. Abnormal flowers. Fig. 26. Staminate flower with sessile gynæceum. One of the petals is divided to the base. Fig. 27. A sepal and a petal are divided to the base. Fig. 28. One lobe of a petal on the left is sepaloid. Another petal on right is divided to the base. Figs. 29–31. Adnation of petals and stamens to the androgynophore, gynophore and ovary. The distinction between androgynophore and gynophore is not clear, × 2.

Figs. 32–35. Dry fruits derived from bi-, tri- and tetracarpellary ovaries with fruit walls removed except in Fig. 32. Placentæ are with remnants of funiculi. Note the compound placentæ in Figs. 34 and 35. × 1.

The tri- and tetracarpellary gynæcea deserve special mention since these conditions have been misinterpreted in the past.

*Tricarpellary gynæceum.*—Figs. 41 to 51 show serial transverse sections of a tricarpellary gynæceum from base upward. The vascular plan of a tricarpellary gynæceum is fundamentally similar to that of a bicarpellary one. Generally the gynophore which is more or less triangular in outline in a transverse section has more bundles than a
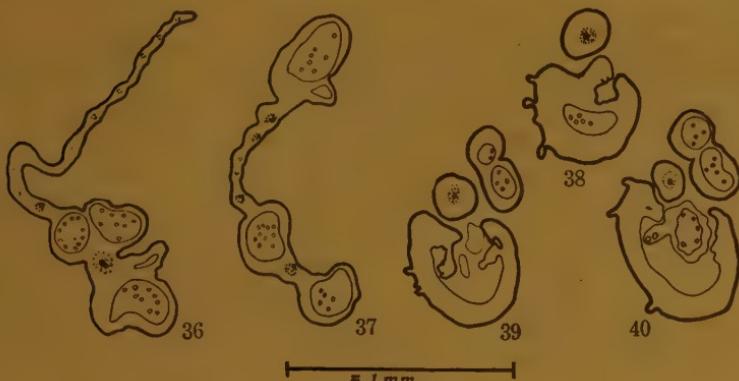
Figs. 36–40. Abnormal floral parts.   Fig. 36.  Petal bearing pollen sacs with pollen grains.  Fig. 37. Petal rudiment functions as connective and bears the anther lobes.  In this figure the connective is elongated and petaloid.  Flg. 38. One of the anther lobes of a stamen shows an almost open gynæceum at the base with ovules attached to the margin.  Note the connective and the pollen sac.  Fig. 39. Open gynæceum with ovules on the incurved margins.  Connective and anther lobes are clear.  Fig. 40. Anther lobe inside the open ovary bears polliniferous ovules with ill-developed pollen sacs.

normal one, twelve or more (Fig. 41).  Formation of three groups of bundles with the passing out of the dorsals in between them is seen in the basal portion of the ovary (Fig. 42).  Out of three groups of bundles one is anterior and the other two are postero-lateral.  The latter are not completely separated from one another and appear like a compound one.  On the inner side of these three groups of vascular bundles there differentiates some procambial tissue which develops into inverted placental strands (Figs. 43–45). The ovarian cavity arises as three separate "loculi" that finally merge at slightly higher level into one (Figs. 43–45).  Each of the three placentæ is a fully developed structure consisting of two halves being separated from one another by a sterile plate of tissue.  Each half bears two rows of ovules which are oriented differently.  The vascular supply of each placental region is perfectly similar to that of a bicarpellary one consisting of an inverted placental strand lying on the inner side of the prominent bundle, the secondary marginal strand (Fig. 46).  The additional carpellary segment is generally somewhat smaller than the others (Figs. 46–48).  The subsequent behaviour of the bundles in the placental region is similar to the condition met with in the bicarpellary ovary (Figs. 48–51).

*Tetracarpellary gynæceum.*—Figs. 52 to 60 show transverse sections of a tetracarpellary gynæceum from base upward.  It appears that the gynophore is somewhat triangular at very early stages but this nature is lost as soon as it expands into the ovary.  In Fig. 57 two placentæ are marked off clearly, while the other two on the anterior side, however, are very close to one another separated by a small cavity.  At a higher level the carpellary segment in between the last two expands
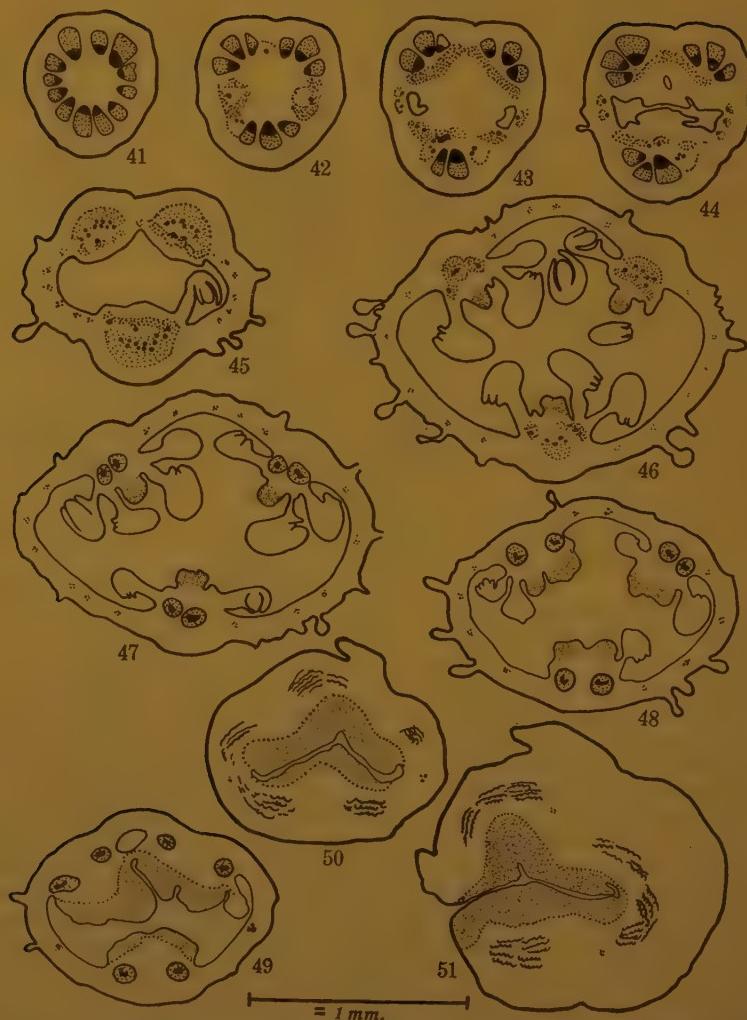
FIGS. 41–51. Serial transverse sections of a tricarpellary ovary from base upwards. Dorsal bundle is clear even in the stigma region (Figs. 49–51).

and separates the two placentæ from one another. Thus in Fig. 58, the four placentæ are clearly seen. But it will be noted that the carpellary segments in the antero-posterior plane which are formed from the third and the fourth carpels, developing spirally, are smaller than the segments of the first two. Each placenta is normal in its structure and vascular supply (Figs. 58–60).

It has been noted that the size of the antero-posterior segments depends largely on the level of appearance of anteroposterior carpels.
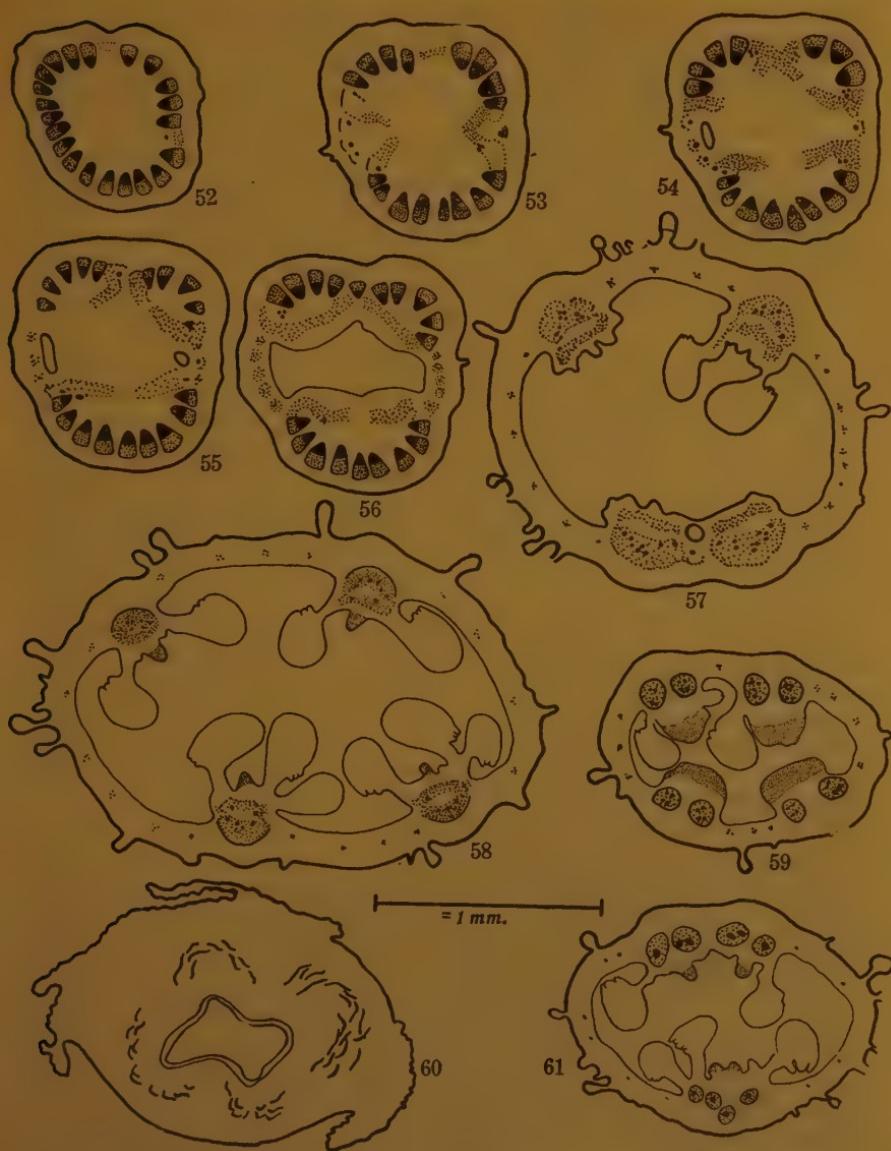
FIGS. 52–60.  Transverse sections of a series of tetracarpellary ovary from base upwards.  Fig. 61.  Cross-section of an ovary with two compound placentæ each having the double vascular supply.

If they appear immediately, after the lateral carpels the segments formed by them may be equal to those of the lateral ones.  Otherwise, they are generally smaller and sometimes may not be formed at all.  In such cases the two placentæ may lie very close to one another forming

a compound structure (Fig. 61) and such a condition has been mis-interpreted as single placenta by Raghavan (1939).

Fruits derived from the tri- and tetracarpellary gynæcea also deserve some mention. In Fig. 33, is shown a tricarpellary condition in which all the three carpels appear to arise very close to one another. In Fig. 34 while the placenta on the left is simple that on the right is compound for some distance and then separates into two, making the ovary clearly tricarpellary in the middle. The same condition is shown in Fig. 35 where the fruit has become tetracarpellary, with two compound placentæ at the base.

## DISCUSSION

*The Sepals.*—The relative position of the two pairs of sepals, the sequence of their divergence and of their vascular traces from the parent stele have attracted some attention in the past. In *Gynandropsis gynandra* the lateral pair of sepals are the first to receive their vascular supply from the receptacle stele and also first to separate from the receptacle (Figs. 8–10). They are followed by median sepals which enlarge more rapidly (anterior sepal being the largest) and soon enwrap the lateral pair. Thus although the lateral sepals are the lowest organs of the flower they are not the outermost parts after certain stage of development (Fig. 17). A similar condition has also been described in certain crucifers (Arber, 1931). Raghavan (1939) on the other hand asserts that in *Gynandropsis* and several other capparids it is the median pair of sepals which are actually the lowest and which receive their vascular supply earlier than the lateral ones. Raghavan and Venkatasubban (1941) reported a similar condition in *Cratæva religiosa* but this has recently been shown to be inocrrect (Puri, 1950). The present author has little doubt that the condition in *Gynandropsis* also has been misinterpreted.

The relative position of the lateral and median sepals appears to have been complicated by some theoretical considerations. It is well known, for instance, that in the Cruciferæ and Capparidaceæ the bracteoles are as a rule lacking. Some authors believe that they were present in the ancestral forms and that it is only during evolution that they have been eliminated. If this were so, and if alternation of floral parts is to be observed then the next floral whorl, *i.e.*, the lowest pair of sepals should occur in antero-posterior plane. Raghavan (1939) supports such a view and he has found some evidence for it in the presence of some structures in *Euadenia aminens* and *Capparis flexuosa* which he calls bracteoles. All this appears to be based on wrong premises. We have obtained fairly convincing proof of the assertion that lateral sepals are the lowest floral whorl. This being so it is not necessary for the bracteoles to occur in the same posi-tion. Thus it becomes clear that bracteoles were never required and consequently they may never have existed in these families, although Alexander (1952) believes in their existence. Structures similar to what Raghavan describes as bracteoles have also been observed in *Gynandropsis* but here they have been interpreted as stipules

of the singal bract. Arber (1931) reports similar structures in many members of the Cruciferæ and she has interpreted them in the same way, calling them squamules. It is possible, therefore, that what Raghavan describes as bracteoles may actually turn out to be stipules.

It is interesting to note the range of variation in the vascular supply of sepals in different species of the Capparidaceæ. In *Gynandropsis* and many others (see Raghavan, 1939) each sepal receives a single trace which branches sooner or later in the sepals. In *Cratæva tapia* and *Polanisia* (Stoudt, 1941) and in *Cartæva religiosa* (Puri, 1950), the sepal marginals arise as branches from the petal strands. In *Capparis lobbiana* (Stoudt, 1941) each sepal receives three traces but they diverge independently leaving a common gap in the central cylinder. *Capparis spinosa* shows a peculiar combination of 1-trace and 3-trace sepals. Here the lateral sepals receive one bundle each whereas the median ones which are larger in size get three traces, the two lateral veins being derived from petal strands (see Eggers, 1935).

The vascular supply of petals and stamens consists of a single trace each and does not merit any comments. The statement of Raghavan (1939) that a "primary supply of three strands" enters into each of the six stamens is obviously incorrect.

*The Gynæceum.*—The composition of the gynæceum and the nature of the carpels in the Capparidaceæ, like those in the Cruciferæ, have long engaged the attention of floral morphologists. The various points of views have been ably summarised in recent works of Eames and Wilson (1928), Eggers (1935), Arber (1938), Stoudt (1941) and Puri (1945, 1950, 1951 and 1952). It is not necessary, therefore, to cover that ground once again. It will suffice to mention just what we consider to be the present state of the problem.

From the recent publications of Puri (1945, 1950, 1951 and 1952), it appears that the problem is well settled in favour of what he calls the *n*-carpellary view (where *n*-represents the number of placentæ). He has shown clearly that there is no support left now for the $2n$ carpellary view as proposed by Eames and Wilson (1928) and later on supported by Stoudt (1941). This being so, the only problem that remains now is about the interpretation of the internal bundles which are inverted. Some authors (Spratt, 1932; Eggers, 1935; Raghavan, 1939) discard this feature as merely insignificant and believe it to be due to some sort of "physiological necessity". Arber (1938) suggests that the inversion is due to an anatomical necessity (a branch that comes out of a concentric bundle naturally becomes inverted). May be that this is so but the present author is inclined, in the present state of our knowledge, to concur with Puri (1950) who suggests the inversion of these bundles as a relic of their past history. According to him the ancestors of the capparid gynæceum had axile placentation, with inverted placental strands. During the change that followed from axile to parietal placentation the inversion of the placental strands has somehow been retained. Such an interpretation may not at the first sight appear to be very plausible for advanced genera like *Cleome* and *Gynandropsis* but for *Cratæva* it is fairly convincing. The present

author, therefore, believes that what holds good for *Cratæva* also holds good for *Gynandropsis* and that the outer and inner (inverted) bundles in the placental regions are best regarded as secondary marginals or septals and placental strands respectively.

*The Placentæ.*—What have been described here as tri- and tetra-carpellary conditions have been interpreted in a very strange and improbable manner by Raghavan (1939) (see also Puri, 1951). He holds, for instance, that in all these cases the gynæceum is bicarpellary and biplacental, each placenta being a double structure and that the two halves of one or both the placentæ may get separated apart more or less from one another. Thus the three and four placental conditions described earlier in this paper have been interpreted as simple modifications of the biplacental condition. While dealing with such cases Raghavan (1939) has obviously mistaken a "double" placenta for a single placenta and a single one for a half placenta. For instance the two placentæ on the posterior side (Fig. 57) have to be interpreted, according to him as two halves of the same placenta and the "Compound" placenta on the lower side in the same figure, as a simple structure. Apparently he has been misled by differences in size of the various carpels, the additional carpels being generally smaller than the original ones. Raghavan and Venkatasubban (1941) offered similar interpretation to tri- and tetracarpellary gynæcea in *Cratæva religiosa.* This has already been shown to be incorrect (Puri, 1950).

In *Gynandropsis* as in many others each placenta is characterised by the following features:—

(1) It is distinguishable into two halves by a sterile vertical protuberance or a small groove.

(2) On each half placenta the ovules are arranged in two vertical rows.

(3) Ovules on two halves of a placenta are oriented in opposite directions.

By applying these criteria to the two upper placentæ in Fig. 46 it can be clearly seen that each of them represents a full placenta and not two half placentæ as Raghavan (1939) suggested. Similarly the large "placenta" on the lower side in Figs. 57 and 61, is a compound structure consisting of four half pacentæ and therefore is equivalent to two full placentæ which have not yet separated apart on account of poor development of the intervening carpellary segments.

## SUMMARY

Vascular anatomy of the flower of *Gynandropsis gynandra* is described. Variations in the number of floral parts and some abnormalities like sepalody, petalody, staminody, pistillody and adnation of different parts are reported and sketched.

The small lateral structures on the pedicel at the points from where the bract margins separate are regarded as stipules of the bract and bracteoles are believed to be absent.

It has been shown that the lateral sepals are the first to receive the vascular supply and to be detached from the receptacle, but later on they generally become enwrapped by the median ones.

Petals and stamens each receives a single trace from the receptacle.

As to the constitution of the carpel the so-called classical interpretation of the capparid gynæceum is supported and it is believed that the placentation in this family is derived from axile placentation. Tri- and tetracarpellary gynæcea and their fruits have been described and their structure discussed.

### ACKNOWLEDGEMENT

### LITERATURE CITED

ALEXANDER, I., 1952. Entwicklungsstudien an Blüten von Cruciferen und Papaveraceen, Planta, 40 : 125-44.

ARBER, A. 1931 *a*. Studies in floral morphology. I. On some structural features of the cruciferous flower. New Phytol. 30 : 11–41.

————. 1931 *b* Studies in floral morphology. II. On some normal and abnormal crucifers : with a discussion on teratology. New Phytol. 30 : 172–203.

————. 1938. Studies in flower structures. IV. On the gynæceum of *Papaver* and related genera. Ann. Bot. N. S. 2 : 649-63.

EAMES, A. J. AND WILSON, C. L. 1928. Carpel morphology in the Cruciferæ. Amer. J. Bot. 15 : 251–70.

EGGERS, O. 1935. Über die morphologische Bedeutung des Leitbundelverlaufes in der Blüten der Rhœadalen und über das Diagramm der Cruciferen und Capparideceen. Arch. Wiss. 24 : 14–58.

MASTERS, M. T. 1869. Vegetable teratology.

PAX, F. AND HOFFMAN, K. 1936. Capparidaceæ. Engler und Prantl's Pflanzenfamilien. 17 B : 146-223.

PURI, V. 1945. Studies in floral anatomy. III. On the origin and orientation of placental strands. Proc. Indian Acad. Sci. 15 : 74–91.

————. 1950. Studies in floral anatomy. VI. Vascular anatomy of the flower of *Cratæva religiosa* with special reference to the nature of the carpels. Amer. J. Bot. 37 : 363–70.

————. 1951. The role of floral anatomy in the solution of morphological problems. Bot. Rev. 17 : 471–553.

————. 1952. Placentation in Angiosperms. Bot. Rev. 18 : 603–51.

————. 1952. Placentation in the Rhœadalean flower. Agra University Extension Lectures.

RAGHVAN, T. S. 1939. Studies in the Capparidaceæ. IV. Floral anatomy and some structural features of the Capparidaceæ. J. Linn. Soc. Bot. London. 52: 239–56.

RAGHAVAN, T. S. AND VENKATASUBBAN, K. R. 1941 *a*. Studies in the Capparidaceæ. VI. Floral structure in *Cratæva religiosa* Forst, with special reference to the morphology of the carpel. Proc. Indian Acad. Sci. B 13 : 109–28.

—————. 1941 *b*. Studies in the Capparidaceæ. VII. The floral morphology of *Cratæva religiosa*. ibid. B 13 : 235–43.

RENDLE, A. B. 1938. Classification of Flowering Plants. Vol. II. Dicotyledons. Cambridge.

SPRATT, E. R. 1932. The gynœcium of the family Cruciferæ. J. Bot. 70 : 309–14.

STOUDT, H N. 1941. The floral Morphology of some of the Capparidaceæ. Amer. J. Bot. 28 : 664–75.

WORSDELL, W. C. 1915–16. The Principles of Plant Teratology.

# KOORCHALOMA, A NEW GENUS OF THE TUBERCULARIACEÆ

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RECENTLY I collected an interesting Tuberculariaceous fungus on dead culms of paddy (*Oryza sativa* Linn.) from a private farm on the road to Poonamallee in the Chingleput District, Madras State. It was found growing as a saprophyte on the substratum, producing salmon to orange coloured sporodochia. I give below a description of the fungus.

Under a hand lens the sporodochia appear to be circular or irregular in outline, separate, and beset with dark, stiff hairs, particularly along the margins. They are saucer-shaped to cup-shaped and entirely superficial, as indicated by a study of sections. They have a maximum diameter of about 1 mm., and are 98–140 $\mu$ tall, the length of the setæ being greater and not considered in computing the height of the fructification. The setæ are simple, unbranched, dark brown in colour, paler towards the tip, long, stiff, erect, straight or bent, broader at the base and narrowing towards the tip which is usually blunt and rounded, many-septate, up to 300 $\mu$ long, and up to 15 $\mu$ broad at the base. The conidiophores are simple, hyaline, cylindrical, 2–4 $\mu$ broad, and compactly arranged parallel and close to each other to form a hymenium. They appear to arise from a substratum of loosely interwoven hyphæ rather than from any distinct stromatic tissue. The conidia are produced acrogenously and singly from the tips of the slender conidiophores, and are hyaline, one-celled and smooth-walled. In shape they are sub-cylindrical or navicular or somewhat fusiform, with the base often somewhat slightly mamillate. Each conidium has a characteristic brush-like apical appendage. The appendage can be seen clearly by simply mounting the material in lacto-phenol; it may be seen more clearly by staining with aqueous methylene blue and mounting in water. When stained with methylene blue, the conidia show 2–5 vacuoles or guttules each. In any case, the most noteworthy feature of the conidium is the brush-like hyaline apical appendage and this appendage is not evanescent when mounted in lacto-phenol; it does not appear, however, to be composed of a large number of distinct threads forming a crown at the tip of the conidium, but the general appearance and shape is unmistakably that of a brush which may or may not be spread out. The conidia are mostly $16 \times 3 \cdot 2$ ($8$–$19 \cdot 2 \times 3 \cdot 2$–$4 \cdot 0$) $\mu$ in size. The appendages are $4 \cdot 8$–$9 \cdot 6 \times 2 \cdot 4$–$9 \cdot 6 \mu$.

The most striking characteristics of the fungus are, of course, its hyaline one-celled conidium with the peculiar brush-like apical

appendage, the bright coloured setose sporodochia and the distinct hyaline cylindrical conidiophores forming a hymenium and producing conidia acrogenously and singly. So far as I am aware, the only genus of the Tuberculariaceæ-Hyalosporæ with setose sporodochia and appendaged conidia is *Neottiosporella* von Hoehnel [=*Neottiosporis* Clements and Shear, an invalid change by the authors, for *Neottiosporella* Hoehnel] (Clements and Shear, 1931, pp. 219, 400). *Neottiosporella* Hoehnel (Hoehnel, 1923, p. 345) "is a *nomen nudum* without formal diagnosis or designation of any species" (Bisby, 1949, p. 40). It may, however, be mentioned, in passing, that the name *Neottiosporella* has recently been used by Graniti (1951) for a fungus which he has named *N. triseti*; indeed, Graniti has formally given a diagnosis for *Neottiosporella* Hoehnel and has designated *N. triseti* as the type of that genus. It is difficult to reconcile Graniti's generic diagnosis (Graniti, 1951, p. 150) with Hoehnel's brief characterisation of his genus in his "System der Fungi Imperfecti Fuckel". For, Hoehnel described the conidia of *Neottiosporella* as "oben mit einigen Cilien"; but Graniti's generic diagnosis of *Neottiosporella* Hoehnel indicates its having conidia which are "utrinque 1-ciliate". In any case, there is nothing in Hoehnel's brief characterisation of his genus to warrant my fungus being placed in that genus; and, as for *Neottiosporella* Hoehnel *sensu* Graniti, I can definitely state, on the basis of Graniti's diagnosis, that my fungus is not congeneric with *Neottiosporella triseti* Graniti. I am, therefore, proposing a new genus to accommodate my fungus. The generic name is derived from Sanskrit *Koorcha=* brush and *loma*=hair.

### Koorchaloma Subramanian gen. nov.

Pertinet ad Fungos Imperfectos, atque ad Hyalosporas.

Sporodochia lucide colorata, setosa, superficialia. Setæ simplices, brunneæ, longæ, septatæ. Conidiophori simplices, hyalini, efformantes seriem hymenialem. Conidia hyalina, semel cellulata, acrogena, haud catenata, singula ornata appendici apicali penicillatæ.

Species typica sequens.

### Koorchaloma madreeya Subramanian sp. nov.

Sporodochia salmonea vel aurantiaca, separata, setosa, superficialia, patellæ similia, figuræ variabilis, usque ad 1 mm. lata, ca. 98–140 $\mu$ alta. Setæ simplices, rigidæ, erectæ, rectæ vel curvatæ, brunneæ, pallidiores atque angustiores ad apicem, septatæ, usque ad 350 $\mu$ longæ, atque ad 15 $\mu$ latæ ad basim. Conidiophori simplices, hyalini, cylindrici, 2–4 $\mu$ lati, efformantes seriem hymenialem. Conidia hyalina, semel cellulata, acrogena, haud catenata, sub-cylindrica, naviculata vel aliquantum fusiformia, levibus parietibus ornata, 8–19·2 $\times 3·2$–4·0 $\mu$ (ut plurimum $16 \times 3·2$ $\mu$), singula ornata appendici apicali penicillatæ, magnitudine appendicis 4·8–9·6$\times 2$·4–9·6 $\mu$.

Typus lectus in culmis emortuis *Oryzæ sativæ* Linn., in loc. Poonamallee High Road, Chingleput District in Statu Madras, die 24 februarii anni 1953, a C.V.S., et positus in Herb. M.U.B.L. sub numero 853.
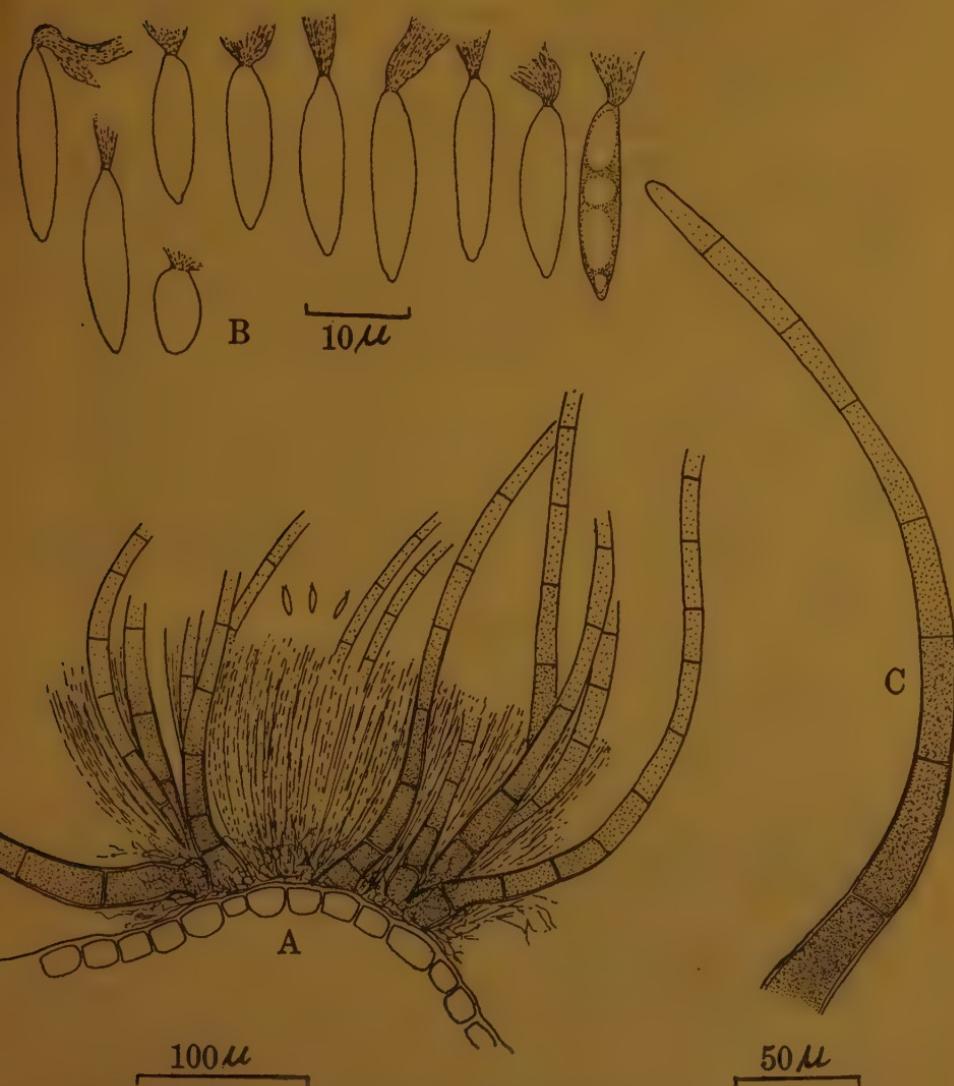
FIG. 1. *Koorchaloma madreeya* from type collection, Herb. M. U. B. L. No. 853. A, section of a sporodochium; B, conidia; C, seta.

## Koorchaloma Subramanian gen. nov.

Fungus imperfectus, hyalosporæ.

Sporodochia bright-coloured, setose, superficial. Setæ simple, brown, long, septate. Conidiophores simple, hyaline, forming a hyme-

nial layer. Conidia hyaline, one-celled, acrogenous, non-catenate, each with a brush-like apical appendage.

Type species:

## Koorchaloma madreeya Subramanian sp. nov.

Sporodochia salmon to orange coloured, separate, setose, superficial, saucer-shaped, of variable outline, up to about 1 mm. broad, about 98–140 $\mu$ tall. Setæ simple, stiff, erect, straight or bent, brown, paler and narrower towards the tip, septate, up to 350 $\mu$ long, up to 15 $\mu$ broad at the base. Conidiophores simple, hyaline, cylindrical, 2–4 $\mu$ broad, forming a hymenial layer. Conidia hyaline, one-celled, acrogenous, non-catenate, sub-cylindrical, navicular or somewhat fusiform, smooth-walled, $8–19 \cdot 2 \times 3 \cdot 2–4 \cdot 0 \mu$ (mostly $16 \times 3 \cdot 2 \mu$), each with a brush-like apical appendage, the appendage measuring $4 \cdot 8–9 \cdot 6 \mu \times 2 \cdot 4–9 \cdot 6 \mu$.

*Habit*: on dead culms of *Oryza sativa* Linn., Poonamallee High Road, Chingleput District, Madras State, 24–2–1953, coll. C.V.S., Herb. M.U.B.L. No. 853.

### REFERENCES

BISBY, G. R. 1949. Generic names of fungi proposed for rejection. Mimeographed Publication No. 6, 59 pp., Commonwealth Mycological Institute, Kew, England.

CLEMENTS, F. E. AND SHEAR, C. L. 1931. The Genera of Fungi. 496 pp. The H. W. Wilson Co., New York.

GRANITI, A. 1951. *Neottiosporella triseti* n. sp. Nuovo G. bot. ital. **58**: 148–51.

HOEHNEL, F. VON. 1923. System der Fungi Imperfecti Fuckel : I. Histiomyceten; II. Synnematomyceten. Mykologischen Untersuchungen und Berichte. 1 (3) : 301–69.

# ROOTING RESPONSES OF TROPICAL LEAVES

## I.  A Report with Seven Species of Isolated Leaves

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### INTRODUCTION

THE application of hormones in the induction  of roots in isolated leaves with a view to correlating the different physiological phenomena of the living cell is of recent origin.  The small amount of investigations carried out in the different parts of the world in  this particular line has been summed up by Gregory and  Samantarai (1950) while studying the physiology of two leaves, *viz*., dwarf French bean and ivy, of the temperate zone.  The present authors with a view to advancing a detailed study of the physiological processes in leaves in relation to their rooting behaviour by different growth hormones have in this work attempted to induce rooting from the petioles of a number of tropical leaves after they have been detached from the parent plants. A preliminary brief report was published earlier (Samantarai and Misra, 1953).

### MATERIAL AND METHOD

Leaves from seven plants, *Dolichos Lablab* Linn., *Canavalia ensiformis* Linn., *Lantana Camara* Linn., *Congea tomentosa* Roxb., *Heliotropium indicum* Linn., *Tropæolum majus* Linn., and *Malvaviscus* sp. were used as materials.  The hormone $\beta$-indolylbutyric acid (I.B.A.) was used in most cases but in one case $\alpha$-naphthylacetic acid (N.A.A.) was also used.   The hormone was dissolved in a few drops of 95% alcohol and then diluted with the requisite quantity of water to make a 500 p.p.m. (parts per million) stock solution which was carefully preserved in a refrigerator.  Whenever a set of experiments was to begin, the stock solution was diluted to lower strengths.

Leaves of approximately uniform size were detached from the parent plants at 8 a.m. for each sampling and brought to the laboratory.  Before treatment the petioles were cleanly cut at the base by means of a razor to facilitate better absorption and to have  the lengths of the petioles uniform.  Then the leaves were thoroughly washed under running tap water to free them from all adhering dirt and  dust particles.  A requisite number of leaves were treated by dipping their petioles upto a depth of one inch in different hormone solutions kept in beakers and left undisturbed for 24 hours inside  the laboratory at room temperature.  After this period of treatment the leaves were washed thoroughly in tap water, care being taken to see that no hormone solution adhered to the petiole or the blade.  In the  absence of this

precaution, as later experience showed, the harmful effect of rotting of the leaves took place. They were then placed in the beakers containing tap water and the beakers were kept in specially prepared plant propagating chambers so as to expose the leaves to adequate amount of sunlight. The inner and outer sides of the chambers were sprayed intermittently with water so as to keep the atmosphere always moist in order to help the leaves to remain fresh.

## EXPERIMENTAL RESULTS

In every case ten replicates were used for each treatment and the same number for the controls. The experimental data for the six kinds of leaves, *Dolichos, Canavalia, Lantana, Congea, Heliotropium* and *Tropæolum* are presented in Table I.

### TABLE I

*Effect of various concentrations of I.B.A. on six kinds of isolated leaves*

| Concentrations of hormones used in p.p.m. | Percentage of leaves rooted | | Average days from treatment initiation to first root appearance | | Average number of roots per leaf | | Average length of roots in cm. per leaf | |
|---|---|---|---|---|---|---|---|---|
| | *Dolichos* | *Canavalia* | *Dolichos* | *Canavalia* | *Dolichos* | *Canavalia* | *Dolichos* | *Canavalia* |
| 100 | 60 | 50 | 14 | 10 | 12 | 3 | 8·5 | 8·2 |
| 50 | 80 | 60 | 14 | 12 | 11 | 3 | 12·3 | 10·5 |
| 20 | 85 | 85 | 15 | 8 | 11 | 5 | 15·1 | 13·1 |
| 10 | 90 | 90 | 15 | 9 | 15 | 7 | 16·2 | 13·8 |
| 5 | 95 | 90 | 16 | 12 | 17 | 6 | 21·4 | 8·5 |
| 2·5 | 95 | 90 | 16 | 19 | 13 | 4 | 14·7 | 5·9 |
| 0 (Control) | 15 | 15 | 27 | 23 | 2 | 2 | 4·9 | 2·6 |
| | *Lantana* | *Congea* | *Lantana* | *Congea* | *Lantana* | *Congea* | *Lantana* | *Congea* |
| 100 | 0 | 10 | 0 | 38 | 0 | 3 | 0 | 1·2 |
| 50 | 70 | 5 | 9 | 39 | 8 | 2 | 59·1 | 0·8 |
| 20 | 67 | 5 | 8 | 39 | 7 | 2 | 73·8 | 0·5 |
| 10 | 95 | 0 | 10 | 0 | 5 | 0 | 26·2 | 0 |
| 5 | 82 | 0 | 11 | 0 | 3 | 0 | 23·3 | 0 |
| 2·5 | 70 | 0 | 11 | 0 | 3 | 0 | 21·3 | 0 |
| 0 (Control) | 10 | 0 | 16 | 0 | 1 | 0 | 3·1 | 0 |
| | *Heliotropium* | *Tropæolum* | *Heliotropium* | *Tropæolum* | *Heliotropium* | *Tropæolum* | *Heliotropium* | *Tropæolum* |
| 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | 60 | 0 | 8 | 0 | 3 | 0 | 5·7 | 0 |
| 20 | 75 | 0 | 9 | 0 | 5 | 0 | 12·5 | 0 |
| 10 | 85 | 0 | 9 | 0 | 6 | 0 | 17·8 | 0 |
| 5 | 90 | 50 | 8 | 14 | 9 | 2 | 31·4 | 1·7 |
| 2·5 | 90 | 40 | 10 | 12 | 8 | 2 | 21·2 | 1·3 |
| 0 (Control) | 20 | 0 | 14 | 0 | 2 | 0 | 2·3 | 0 |

A study of Table I shows that *Dolichos* leaf produces profuse roots in almost all the concentrations of the hormone. The percentage of

leaves rooted shows a gradual rise with lower dilutions. The average number of roots per leaf is highest in 5 p.p.m. and also the average length of the roots is maximum in that concentration. *Canavalia* leaf is also very responsive to hormone solutions. The first root appeared earliest in 20 p.p.m. The percentage of leaves rooted are very high in the four concentrations of 20, 10, 5 and 2·5 p.p.m. All the leaves of *Lantana* rotted away in the strongest solution of 100 p.p.m. The percentage of leaves rooted is fairly high in all the concentrations from 50 to 2·5 p.p.m., the highest value of 95% being obtained in 10 p.p.m. solution, but the roots attained greatest length in 20 p.p.m. The response of *Congea* leaf is entirely different. Here rooting has been induced only in the three higher concentrations and that too, in a very small percentage of leaves after a very long period. The number of roots are 2 to 3 per leaf and they are of very small length by the time the experiment was discontinued. Although the texture of this leaf is fairly thin and soft it is rather interesting to note that concentrations lower than 20 p.p.m. could not induce any rooting. Coming over to *Heliotropium* leaves it is seen that 100 p.p.m. of the hormone had a toxic effect and all the leaves died away in that concentration. A fairly high percentage of leaves has produced roots in all concentrations from 50 to 2·5 p.p.m. The average length of roots per leaf is greatest in 5 p.p.m. It became very difficult to keep the leaves of *Tropæolum* in fresh condition. In spite of constant water sprinkling, in most of the cases they rotted away. Only in the two lower concentration sets of 5 and 2·5 p.p.m., roots have appeared in 50 and 40% of the total leaves·studied. The average number of roots per leaf in each case is only two and length of the roots is very insignificant.

In case of *Malvaviscus* leaves the hormone used was N.A.A. The results are presented in Table II.

TABLE II

*Effect of various concentrations of N.A.A. on the isolated leaves of Malvaviscus*

| Concentrations of hormones used in p.p.m. | Percentage of leaves rooted | Average days from treatment initiation to first root appearance | Average number of roots per leaf | Average length of roots in cm. per leaf |
|---|---|---|---|---|
| 100 | 0 | 0 | 0 | 0 |
| 50 | 20 | 33 | 2 | 2·3 |
| 20 | 25 | 29 | 3 | 2·5 |
| 10 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 |
| 2·5 | 0 | 0 | 0 | 0 |
| 0 (Control) | 0 | 0 | 0 | 0 |

The petiole is comparatively woody in this case. The response to the hormone solutions is therefore very feeble. In 50 p.p.m. set after 33 days, only in 20% of the leaves have roots appeared. Their number and length are very small. In most of the other concentrations the leaves have not produced any roots.

## DISCUSSION

This is the first of its kind to report the induction of rooting in isolated tropical leaves by the application of synthetic hormones. Out of these seven kinds of leaves tried, *Lantana Camara, Dolichos Lablab, Canavalia ensiformis* and *Heliotropium indicum* proved to be more responsive than *Congea tomentosa, Malvaviscus* sp. and *Tropæolum majus*. In the first group of leaves roots have been profusely produced from the petioles almost at all concentrations tried from 100 p.p.m. to 2·5 p.p.m. The highest concentration of 100 p.p.m. has produced a toxic effect on the leaves of *Lantana Camara* and *Heliotropium indicum* indicated by the decay of all the leaves in a week or so. *Congea tomentosa* and *Malvaviscus* leaves have taken the longest time of 38 and 29 days respectively for the appearance of roots since the time of treatment with hormones. The various responses such as the percentage of leaves, the average number of roots per leaf and the average length of roots per leaf, all vary with the various types of leaves. So the rooting response induced by hormones is varietal in character. In control set of the leaves of *Lantana Camara, Dolichos Lablab, Canavalia ensiformis* and *Heliotropium indicum* a small percentage of leaves has nevertheless produced roots but their number and length are very insignificant in comparison with the treated sets. It is suggested that by following this technique of maintaining detached single leaves quite fresh by its tuft of induced roots it is possible to study accurately the different metabolic processes taking place inside a living cell.

## SUMMARY

By the application of very dilute aqueous solutions of synthetic hormones like β-indolylbutyric acid and α-naphthylacetic acid, roots have been induced from the petioles of isolated leaves of *Dolichos Lablab, Canavalia ensiformis, Lantana Camara, Congea tomentosa, Heliotropium indicum, Tropæolum majus* and *Malvaviscus* sp. The responses to the synthetic hormones used indicated by the percentage of leaves rooted, the time taken for the induction of rooting, the average number of roots per leaf and the average length of roots per leaf are recorded. The responses seem mostly varietal. Certain leaves, e.g., *Dolichos, Canavalia, Lantana* and *Heliotropium* responded well. For leaves like *Tropæolum* even very dilute solutions proved toxic. On the other hand leaves like *Malvaviscus* and *Congea* having woody petioles were mostly insensitive even up to 100 p.p.m.

## REFERENCES

1. GREGORY, F. G. AND SAMANTARAI, B. 1950. Factors concerned in the rooting responses of isolated leaves. J. Expt. Bot. 1: 159–93.

2. SAMANTARAI, B. AND MISRA, G. 1953. Hormone induced rooting in isolated leaves. Sci. & Cult. 18: 388–89.

# *PLAGIONEMA*, A NEW GENUS OF THE SPHÆROPSIDALES

By C. V. Subramanian and K. Ramakrishnan

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AMONGST the collections of fungi made from Tirumalai Hills (Andhra State) by one of us (K. R.) during a visit in August 1951 was a pycnidial fungus occurring as a saprophyte on decaying leaves and pods. Three collections on three different substrata were made. Since then, the same fungus has been observed to occur on a variety of substrata in and around Madras. Altogether twelve collections were made on different substrata. Of these, eleven were on decaying leaves and one on a decaying leguminous pod. The fungus has been found to occur particularly in leaf litter. It was seldom found on leaves on the surface of the litter, but usually appeared to prefer leaves which were buried. It was also noticed that it seldom occurred in moist situations. In fact, in all cases the leaves were dry and brittle when collected.

## DESCRIPTION OF THE FUNGUS

The following description is based on a study of the twelve collections:—

The fungus forms black, slightly raised, circular, convex pycnidia regular in outline, up to 2 mm. in diameter, on both surfaces of the substrata. The pycnidia occur singly and have not been observed to coalesce. They are opaque, with a central, somewhat raised, shining spot when viewed through a lens; but there is no ostiole for the pycnidium.

In vertical section the pycnidium is lenticular; it is intra-epidermal and has a well-defined upper wall (Fig. 1). This wall is merged with the cuticle above and has two distinct layers of cells: (i) the first, which is immediately below the cuticle, is a dark coloured tissue of 2 or 3 tiers of cells the outlines of which could not be clearly seen, and (ii) the second, which is the inner layer, consists of sub-hyaline, somewhat elongated cells with rounded ends. Below, the pycnidial wall consists of 4–6 tiers of brownish, slightly thick-walled, polygonal cells (Fig. 2). Over this is a layer of hyaline, thin-walled cells from each of which one or more conidiophores arise (Fig. 3). The conidiophores are hyaline and lageniform, each with a stout, short base and a slender neck.

The conidia are produced singly from the tips of the conidiophores and are hyaline. In mass, they are slightly coloured. The mature
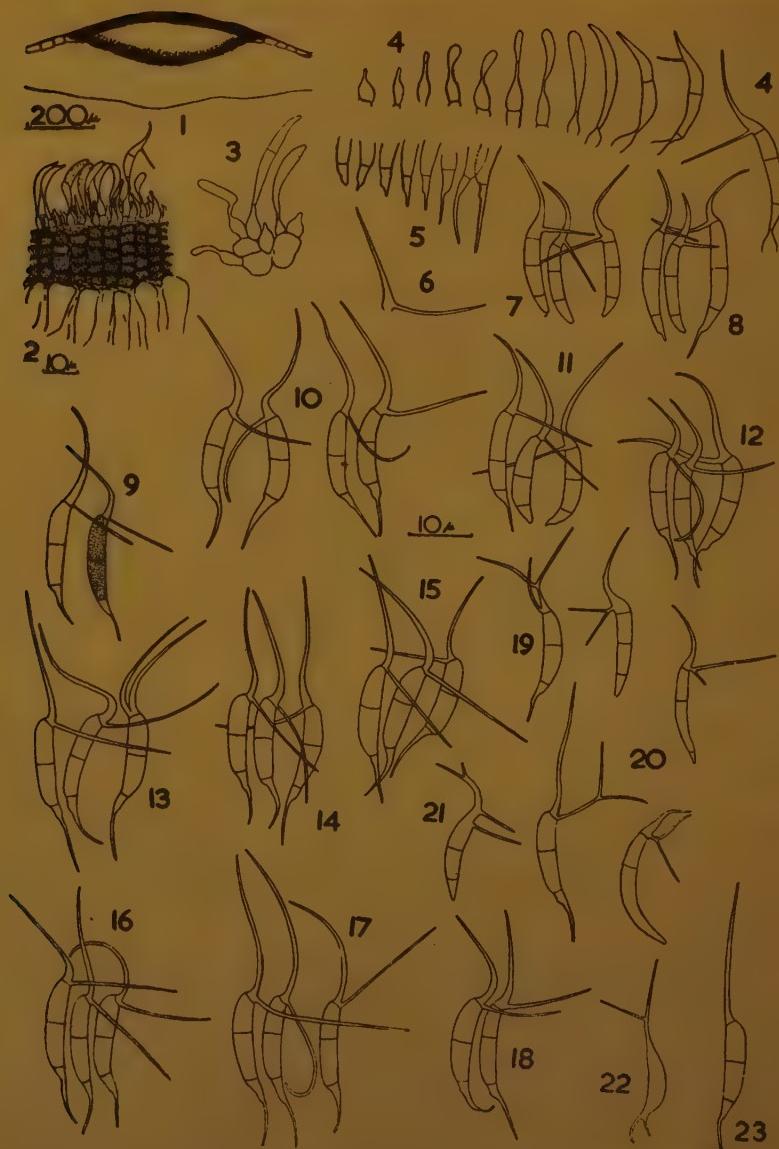
FIGS. 1–23. *Plagionema indica.*—Fig. 1. Section of a pycnidium (Herb. M.U.B.L. No. 354). Fig. 2. A portion of the section of the pycnidium, showing conidiophores and conidia (Herb. M.U.B.L. No. 560). Fig. 3. Conidiophores and young conidia (Herb. M.U.B.L. No. 355). Fig. 4. Stages in the development of the conidium. Fig. 5. Stages in the development of the basal appendage of the conidium. Fig. 6. An apical cell with its lateral appendage broken off from the rest of the conidium. Figs. 7–18. Conidia from twelve collections (Herb. M.U.B.L. Nos. 354, 355, 356, 519, 520, 521, 553, 557, 558, 559, 560, 612). Figs. 19–23. Some abnormal conidia.

conidium (Figs. 7–18) is dorsiventral, cylindrical in the middle and narrowed towards either end, slightly curved and 3-septate. The apical cell of the conidium tapers into a long, usually curved, filiform tail, and bears on its concave side near its base immediately above the cross-wall, a long, hyaline lateral appendage. The basal cell of the conidium tapers into a hyaline, slender, pointed, straight or curved appendage which is usually shorter than the lateral appendage or the caudate apex of the conidium. Conidia, $34 \times 3$ $(23–45 \times 2 \cdot 6–3 \cdot 3) \mu$; lateral appendage, 17 $(6–29) \mu$ long; basal appendage, 7 $(1–12) \mu$ long.

The various stages in the development of the conidium are shown in Figs. 4 and 5. The conidium arises as a small, hyaline, pyriform swelling at the tip of the conidiophore. This swelling elongates and also bulges and, very early during development, it is cut off from the conidiophore by a cross-wall. As the young conidium elongates, its characteristic curvature appears. The next stage in the development is marked by further elongation of the conidium and narrowing of its tip into a short beak. A septum is formed about the middle of the conidium at this stage. This is followed by the formation of a second septum between the first one and the base of the conidium. The apical cell further elongates and assumes the characteristic filiform shape already described. Even before the apical cell attains its characteristic shape, a short outgrowth is formed on the concave side of the conidium a little below the apex. A septum is then formed in the conidium immediately below this lateral outgrowth, the conidium thus becoming 4-celled. The lateral outgrowth elongates and becomes the characteristic lateral appendage. During earlier stages of development the lateral outgrowth is usually straight, but in a mature conidium it may be more or less curved. Conidia with fully-formed lateral appendages have been observed attached to conidiophores; no basal appendages have been seen in such conidia. The basal appendage apparently develops only after the conidium is shed into the cavity of the pycnidium. In a large number of conidia which have been shed from the conidiophores, various stages in the development of the basal appendage have been seen. This appendage arises from the blunt base of the conidium as a continuation of the concave side of the conidium and attains a maximum length of $12 \mu$. Cells of the young conidium are stained uniformly with cotton blue or acid fuchsin; in mature conidia, however, the apical cells and the appendages do not stain and are apparently devoid of contents.

Some abnormal conidia were seen in some collections. These abnormalities relate to the appendages or the apical cell: (i) the tail of the apical cell may be forked into two (Fig. 19); (ii) the lateral appendage may be forked into two (Fig. 20); (iii) there may be two lateral appendages arising from the apical cell (Fig. 21); (iv) there may be two basal appendages (Fig. 22); and (v) the lateral appendage may not be developed (Fig. 23). These abnormalities, however, were very rare.

3

Details of measurements of conidia, etc., of the twelve collections studied are given below:

| Herb. M.U.B.L. No. | Conidium $\mu$ | Lateral appendage Length $\mu$ | Basal appendage Length $\mu$ |
|---|---|---|---|
| 354 | $30 \times 3$ $(23-34 \times 2 \cdot 6-3 \cdot 3)$ | 11 ( 6–15) | 6 (4–7) |
| 355 | $30 \times 3$ $(24-35 \times 2 \cdot 6-3 \cdot 3)$ | 12 ( 9–17) | 6 (3–7) |
| 356 | $28 \times 3$ $(24-35 \times 2 \cdot 6-3 \cdot 3)$ | 13 ( 9–17) | 6 (4–9) |
| 519 | $34 \times 3$ $(29-39 \times 2 \cdot 6-3 \cdot 3)$ | 17 (11–20) | 7 (4–9) |
| 520 | $32 \times 3$ $(24-35 \times 2 \cdot 6-3 \cdot 3)$ | 15 (11–20) | 6 (3–9) |
| 521 | $34 \times 3$ $(28-39 \times 2 \cdot 6-3 \cdot 3)$ | 17 (11–20) | 6 (4–9) |
| 553 | $39 \times 3$ $(33-44 \times 2 \cdot 6-3 \cdot 3)$ | 23 (16–29) | 9 (4–12) |
| 557 | $33 \times 3$ $(24-39 \times 2 \cdot 6-3 \cdot 3)$ | 18 (11–25) | 6 (4–9) |
| 558 | $39 \times 3$ $(31-45 \times 2 \cdot 6-3 \cdot 3)$ | 20 (16–24) | 7 (1–10) |
| 559 | $31 \times 3$ $(24-37 \times 2 \cdot 6-3 \cdot 3)$ | 15 (11–19) | 5 (3–9) |
| 560 | $37 \times 3$ $(28-42 \times 2 \cdot 6-3 \cdot 3)$ | 19 (13–25) | 8 (3–10) |
| 612 | $38 \times 3$ $(34-44 \times 2 \cdot 6-3 \cdot 3)$ | 18 (14–22) | 7 (3–10) |

Dehiscence is by radial cracking of the top of the pycnidium. The cracks appear to start from a slightly raised central point. This point can be seen very clearly in unopened pycnidia.

To our knowledge the fungus mentioned here has so far not been described. It is therefore necessary to place it in a new genus. The name *Plagionema* (indicative of the lateral appendage) was very kindly suggested by Mr. E. W. Mason.

**Plagionema** SUBRAMANIAN AND RAMAKRISHNAN gen. nov.

Pycnidia black, circular, dimidiate, scattered, intra-epidermal, astomous, opening by cracks radiating from the centre, not becoming free round the margin, unilocular, with a pseudo-parenchymatous wall all round, the upper half sterile, the lower fertile. Conidiophores erect, arising from the lower half of the wall. Conidia hyaline, dorsiventral, slightly curved, 4-celled, the apical cell tapering into a long, hyaline, curved, filiform tail, and bearing, on its concave side, a long, hyaline, lateral appendage near its base; the basal cell of the conidium with a hyaline, slender, pointed, straight or curved, terminal appendage.

*Type species*

**Plagionema indica** SUBRAMANIAN AND RAMAKRISHNAN sp. nov.

Pycnidia amphigenous, black, circular, with a slightly raised central point, scattered, dimidiate, intra-epidermal, astomous, opening by

cracks radiating from the centre, unilocular, with a pseudo-parenchymatous wall all round, the upper half sterile, the lower fertile. Conidiophores arising from lower half of the wall, erect, lageniform, with a short, stout base and a slender neck, $7 \times 3 \cdot 5 \mu$; conidia hyaline, dorsiventral, slightly curved, 4-celled, cylindrical in the middle, and narrowed towards either end, apical cell of the conidium tapered into a long, hyaline, usually curved, filiform tail and bearing, on its concave side, near its base a long, hyaline, lateral appendage measuring 17 (11–20) $\mu$; the basal cell of the conidium tapering into a hyaline, slender, pointed, straight or curved appendage measuring 7 (4–9) $\mu$; conidia, $34 \times 3$ (29–39 $\times 2 \cdot 6$–3 $\cdot 3$) $\mu$.

Type collection: on dead leaves of *Azadirachta indica* A. Juss. (Meliaceæ), Herb. M.U.B.L. No. 519, University Botany Laboratory campus, Madras, 22–9–1951, coll. K. Ramakrishnan and C. V. Subramanian.

Paratype collections: on dead leaves of *Bignonia* sp. (Bignoniaceæ) Herb. M.U.B.L. No. 520, University Botany Laboratory campus, 22–9–1951, coll. C. V. Subramanian and K. Ramakrishnan; on dead leaves of *Achras sapota* Linn. (Sapotaceæ), Herb. M.U.B.L. No. 557, *Mangifera indica* Linn. (Anacardiaceæ), Herb. M.U.B.L. No. 558, *Psidium guajava* Linn. (Myrtaceæ), Herb. M.U.B.L. No. 559, and *Swietenia mahagoni* Linn. (Meliaceæ), Herb. M.U.B.L. No. 560, Agri-Horticultural Society's Garden, Madras, 8–10–1951, coll. C. V. Subramanian.

Other collections: on dead leaves of *Ficus* sp. (Moraceæ), Herb. M.U.B.L. No. 354, *Zizyphus ænoplia* Mill. (Rhamnaceæ), Herb. M.U.B.L. No. 355, and a dead leguminous pod, Herb. M.U.B.L. No. 356, Tirumalai Hills, Andhra State, 22–8–1951, coll. K. Ramakrishnan; on dead leaves of *Lantana aculeata* Linn. (Verbenaceæ), Herb. M.U.B.L. No. 521, University Botany Laboratory campus, Madras, 24–9–1951, coll. C. V. Subramanian; on dead leaves of *Hugonia mystax* Linn. (Linaceæ), Herb. M.U.B.L. No. 553, Christian College campus, Tambaram, Madras State, 30–9–1951, coll. C. V. Subramanian and K. Ramakrishnan; of *Ficus bengalensis* Linn. (Moraceæ), Herb. M.U.B.L. No. 612, University Botany Laboratory campus, Madras, 6–11–1951, coll. C. V. Subramanian.

## Plagionema SUBRAMANIAN AND RAMAKRISHNAN gen. nov.

Pycnidia nigra, circularia, dimidiata, dispersa, intra-epidermalia, astoma, ex centro per fissuras radiantes aperientia, circa marginem haud dehiscentia, unilocularia, pariete pseudo-parenchymatico circumdata, dimidium superius ejus sterile, inferius fertile. Conidiophora erecta, ex dimidio inferiore surgentia. Conidia hyalina, dorsiventralia, paullum curvata, 4-cellulata, cellula apicalis cujusque in caudam longam filiformen producta, et prope basim ejus in latere concavo, appendice laterali, longa, hyalina, ornata; cellula basalis cujusque appendice terminali, hyalina, tenui, acuta, recta vel curvata prædita.

*Species typica*

**Plagionema indica** SUBRAMANIAN AND RAMAKRISHNAN sp. nov.

Pycnidia amphigena, nigra, circularia, ornata puncto centrali tenuiter elevato, dispersa, dimidiata, lenticularia in sectione, intra-epidermalia, astoma, ex centro per fissuras radiantes aperientia, circa marginem haud dehiscentia, unilocularia, pariete pseudoparenchymatico circumdata, dimidium superius ejus sterile, inferius fertile. Conidio-phori surgunt ex dimidio inferiore, erecti, lageniformes, præditi brevi atque crassa basi, et tenuique collo, $7 \times 3 \cdot 5 \mu$; conidia hyalina, dorsi-ventralia, paullum curvata, 4-cellulata, cylindrica in medio, angustiora ad utrumque apicem; conidii cellula apicalis desinit in comam longam, hyalinam, ut plurimum curvatum, filiformem, estque ornata ad latus concavum prope basim appendici longo, hyalino, laterali, magnitud. 17 (11–20) $\mu$; cellula basalis conidii desinit in appendicem hyalinum, tenuem, acutum, rectum vel curvatum, terminalem, magnitud. 7 (4–9) $\mu$; conidia, $34 \times 3$ (29–39 $\times 2 \cdot 6$–3 $\cdot 3$) $\mu$.

Typus lectus in foliis mortuis *Azadirachtæ indicæ* A. Juss. (Meli-aceæ), Herb. M.U.B.L. No. 519, University Botany Laboratory campus, Madras, 22–9–1951, a K. Ramakrishnan et C. V. Subramanian.

Paratypi lecti in foliis mortuis *Bignoniæ* sp. (Bignoniaceæ), Herb. M.U.B.L. No. 520, University Botany Laboratory campus, Madras, 22–9–1951, a C. V. Subramanian et K. Ramakrishnan; lecti etiam in foliis mortuis *Achras sapotæ* Linn. (Sapotaceæ), Herb. M.U.B.L. No. 557, *Mangiferæ indicæ* Linn. (Anacardiaceæ), Herb. M.U.B.L. No. 558, *Psidii guayavæ* Linn. (Myrtaceæ), Herb. M.U.B.L. No. 559, atque *Swieteniea mahagoni* Linn.(Meliaceæ), Herb. M.U.B.L. No. 560, in hortu Societatis Agri-Hortic., Madras, die 8–10–1951 a C. V. Subramanian.

Aliæ collectiones: in foliis emortuis *Fici* sp. (Moraceæ), Herb. M.U.B.L. No. 354, *Zizyphi ænopliæ* Mill. (Rhamnaceæ), Herb. M.U.B.L. No. 355, atque in folliculo quodam leguminoso, Herb. M.U.B.L. No. 356, in loco Tirumalai Hills, Andhra State, 22–8–1951, a K. Ramakrishnan; in foliis emortuis *Lantanæ aculeatæ* Linn. (Verbenaceæ), Herb. M.U.B.L. No. 521, University Botany Laboratory campus, Madras, die 24–9–1951, a C. V. Subramanian; in foliis emortuis *Hugoniæ mystacis* Linn. (Linaceæ), Herb. M.U.B.L. No. 553, Christian College campus, Tambaram, Madras State, 30–9–1951, a C. V. Subra-manian et K. Ramakrishnan; atque in foliis emortuis *Fici bengalensis* Linn. (Moraceæ), Herb. M.U.B.L. No. 612, University Botany Labo-ratory campus, Madras, die 6–11–1951, a C. V. Subramanian.

The type collection and the paratype collections are deposited in the Herbarium Cryptogamæ Indiæ Orientalis, New Delhi, India, the Herbarium of the Commonwealth Mycological Institute, Kew, England, and the Herbarium of the University Botany Laboratory, Madras, India.

# TWO MORE ABNORMAL FEMALE RECEPTACLES OF ASTERELLA BLUMEANA NEES.[1]

## By S. K. Pandé and K. P. Srivastava

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ABNORMAL sexual shoots have now and again been described in several genera of the Marchantiales, *e.g.*, Goebel (1880), Taylor (1836), Lindberg (1875), Klien (1881), Townsend (1889), Müller (1906–11), Earnst (1907, 1908), Coker (1909), Cutting (1910), Campbell (1918), Peissel (1925), Haupt (1926), Bergdolt (1926), O'Hanlon (1927), Kashyap (1929), Heberlein (1929), Srinivasan (1939), Burgeff (1943) Pandé, and Srivastava and Khan (1953). Recently Pandé, Srivastava and Khan (1953 *a*) described some abnormal female receptacles of *Asterella blumeana*, a member of the Marchantiales assigned to the Rebouliaceæ (Evans, 1939). In the present article two more abnormal female receptacles of this species collected from the W. Himalayas, different from those described earlier, are dealt with.

*Specimen* 1.—This specimen (Figs. 2 *a* and 2 *b*) is comparatively more robust than an ordinary plant (Fig. 1). The stalk of its carpocephalum is forked above and, as compared to normal cases, is shorter and stouter. Both the branches of the stalk subtend normal receptacles lying very close to each other and each receptacle carries three involucres two of which are fertile and subtend normal perianths, while the third is abortive. The sporophytes have not fully matured but are otherwise normal. Just behind the base of the stalk there is a small male receptacle (Fig. 2 *a*, *m.r.*). The arms of the stalk are comparatively thicker than the stalk of a normal receptacle (Fig. 1) and, as in normal cases (Fig. 4), each includes a single rhizoidal furrow (Fig. 5 *a*). Below the point of bifurcation the stalk is greatly flattened (Fig. 5 *b*) and has two rhizoidal furrows. This condition persists even through the fused portion of the stalk (Figs. 5 *c* to 5 *e*) and can be followed literally to its very base. The fused portion of the stalk is thus comparable to the stalk of some more complex members of the Marchantiales that possess two rhizoidal furrows.

*Specimen* 2.—This specimen (Figs. 3 *a* and 3 *b*), at a superficial glance, does not show much difference from a normal specimen except that the carpocephalum is more robust and the stalk is comparatively thicker and somewhat flattened at its distal end. Behind the stalk of the female receptacle there is a small male receptacle (Fig. 3 *a*, *m.r.*). The female receptacle bears three involucres, one of which subtends a
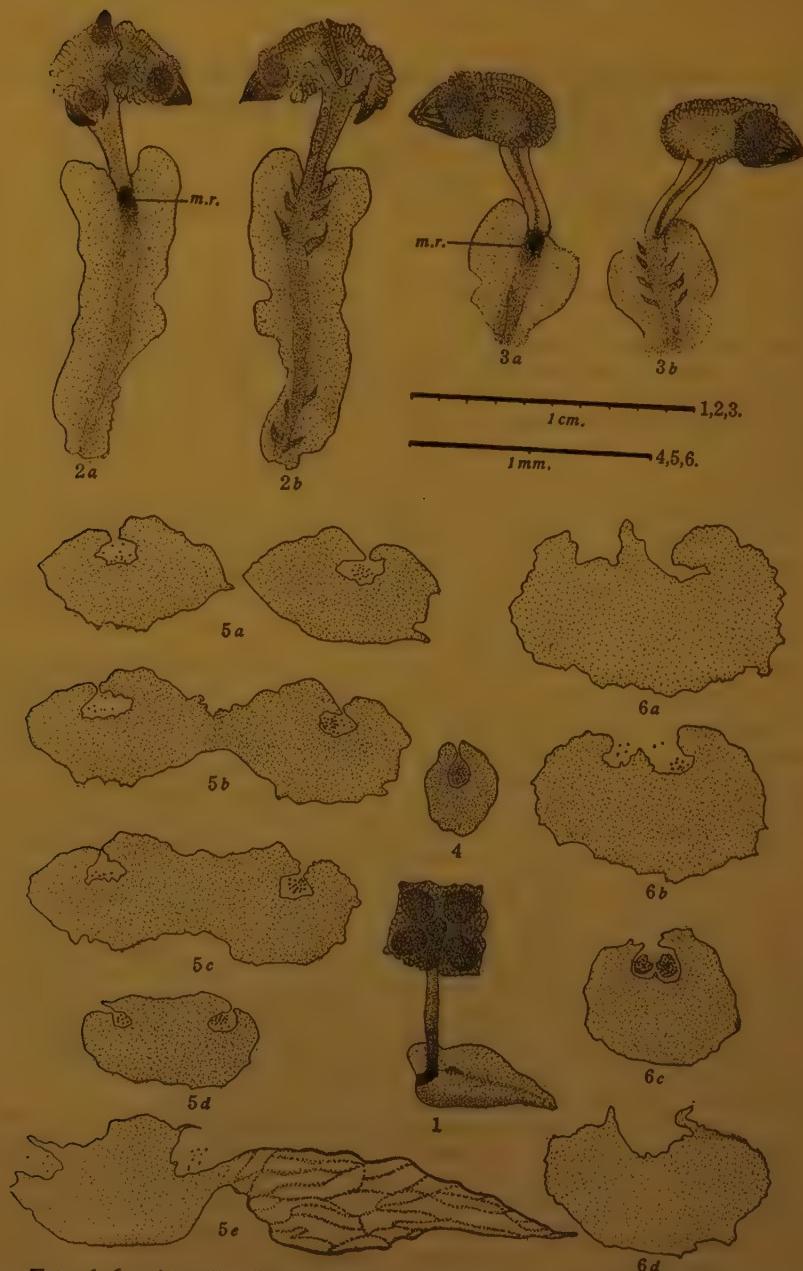
FIGS. 1–6. *Asterella blumeana.*—Fig. 1. Normal plant. Fig. 2. Abnormal specimen 1. Note the bifurcated stalk. *a*, dorsal, *b*, ventral, *m.r.*, male receptacle. Fig. 3. Abnormal specimen 2. *a*, dorsal, *b*, ventral, *m.r.*, male receptacle. Fig. 4. Transverse section of stalk of normal receptacle. Fig. 5. Transverse

sections of stalk of specimen 1. *a,* above point of bifurcation; *b,* below point of bifurcation, *c,* near about the middle; *d* and *e,* near the base. Fig. 6. Transverse sections of stalk of abnormal specimen 2. *a,* near the apex. Note the distinct septum between the two rhizoidal furrows; *b,* above the middle ; *c,* a little above the base; and *d,* near the base. Note that in *d,* the septum has totally disappeared.

mature sporophyte while the other two are abortive. The mature sporophyte has the usual type of spores and elaters. An examination of the serial sections of the stalk of this specimen near the apex (Fig. 6 *a*) reveals that, though externally the stalk is single and without any evidence of branching, it has two rhizoidal furrows separated by a definite partition (Fig. 6 *a*). As the sections of the stalk are followed downwards towards the base (Figs. 6 *b,* 6 *c* and 6 *d*) the septum, separating the two rhizoidal furrows, becomes gradually less and less pronounced and is ultimately eliminated with the result that the two rhizoidal furrows become confluent and the septum between them disappears. The stalk in this part shows only one rhizoidal furrow as in normal specimens. Its groove is comparatively shallower and broader.

### DISCUSSION

It is a well-known fact that an individual in its life-history may sometimes show abnormalities that are best interpreted as reversion to ancestral characters. Viewed from this angle the abnormal carpocephala with two rhizoidal furrows in the stalk, described here, would indicate that forms like *Asterella* have probably arisen from some higher type, such as *Marchantia* or one of its allies, in which the stalk of the carpocephalum had two rhizoidal furrows. This view is further strengthened by the structure of the stalk of the female receptacle of specimen 2, which shows a gradual elimination of the septum separating the two rhizoidal furrows of the stalk till ultimately only one rhizoidal furrow is left. It thus shows a transitional stage between the ancestral type with two rhizoidal furrows in the stalk, and the existing condition in *Asterella* with a single rhizoidal furrow.

Another important conclusion resulting from these observations is that the carpocephalum of *Asterella blumeana* is a branch system, a conclusion arrived earlier by Cavers (1911) and Campbell (1928).

The carpocephalum of the Marchantiales represents a modified shoot. Leitgeb (1881) distinguishes three types of carpocephala in the Marchantiaceæ:—

1. With furrow-less stalk and one archegonium in each involucre, *e.g., Plagiochasma* and *Clevea.*

2. With a single groove in the stalk and a single archegonium in each involucre, *e.g.,* Astroporæ, Operculatæ and *Conocephalum.*

3. The composite type with two furrows in the stalk and several archegonia in each involucre, *e.g., Marchantia.*

According to Leitgeb (*l.c.*) the first type of carpocephalum represents the simplest type and is purely an outgrowth of the thallus. The

second type he regards as a single branch in which the growing point produces the carpocephalum without undergoing dichotomy. His third type is, however, the most advanced one and represents a branch system, the growing point dividing repeatedly during the formation of the carpocephalum. Later investigations by Cavers (1911) and Campbell (1928) have shown that there is no distinction between the second and third type of the carpocephalum of Leitgeb (*l.c.*) and, as Cavers (*l.c.*, p. 54) remarks—"We are probably justified in regarding the carpocephalum which terminates the apical growth of the thallus as being in all cases formed by repeated dichotomy of the apex, resulting in from two to sixteen growing points, each of which may produce either a single archegonium or a series of archegonia." Campbell (1928) has shown that the carpocephalum in *Asterella californica* is a branch system. The abnormal branched receptacles of *A. blumeana*, described by us, furnish further evidence in support of this view.

## ACKNOWLEDGEMENTS

## LITERATURE CITED

BERGDOLT, E. 1926. Untersuchungen über Marchantiaceen. Bot. Abhand. 10 : 1–86.

*BURGEFF, H. 1943. Genetische studien an *Marchantia*, Jena.

CAMPBELL, D. H. 1918. Studies on some East Indian Hepaticæ. Ann. Bot. 32: 319–38.

————. 1928. The Structure and Development of Mosses and Ferns. New York.

CAVERS, F. 1911. The Interrelationships of Bryophyta. New Phytol. Reprint No. 4, London.

COKER, W. C. 1909. Some rare abnormalities in Liverworts. The Bryologist, 12: 104–105.

CUTTING, E. M. 1910. On androgynous receptacles in *Marchantia*. Ann. Bot. 24: 349–57.

*ERNST, A. 1907. Über androgyne Infloreszenzen bei *Dumortiera*. Ber. Deutsch. Bot. Gessels. 25: 455–64.

*————. 1908. Untersuchungen über Entwicklung, Bau und Verteilung der Infloreszenzen von *Dumortiera*. Annales du Jard. bot. de Buitenzorg, 2nd Seris. 7: 153–223.

EVANS, A. W. 1939. The Classification of Hepaticæ. Bot. Rev. 5: 49–96.

*GOEBEL, K. 1880. Über die Verzweigung dorisventraler Sprosse. Arb. des Bot. Instit. in Wurzburg. Bd. 2, Heft 3: 353–436.

HAUPT, A. W. 1926. Morphology of *Preissia quadrata*. Bot. Gaz., 82: 30–54.

HEBERLEIN, E. A. 1929. Morphological studies on a new species of *Marchantia*. Ibid. 88: 417–29.

KASHYAP, S. R. 1929. Liverworts of the Western Himalayas and the Punjab Plain. Part I. Lahore.

*KLIEN, J. 1881. Über Sprossungen an den Inflorescenzstielen von *Marchantia polymorpha*. Bot. Zentralbl. 5: 26–28.

*LINDBERG, S. O. 1875. Hepaticæ in *Hibernia mense* Julii 1873 lactæ. Act. Soc. Scient. Fennicæ, 10: 468.

LEITGEB, H. 1881. Untersuchungen über die Lebermoose. 6: Die Marchantiaceen.

MÜLLER, K. 1906-11. Rabenhorst's Kryptogamen-Flora. 6: Lebermoose (1).

O'HANLON, M. E. 1927. A study of *Preissia quadrata*. Bot. Gaz. 84: 208–18.

PANDÉ, S. K., SRIVASTAVA, K. P. AND KHAN, S. A. 1953. On some anomalous female receptacles of *Asterella khasiana* (Griff.). Mitt. The Bryologist. 56 (In Press).

————. 1953a. On some abnormal female receptacles of *Asterella blumeana* Nees. Proc. Indian Acad. Sci. 38B: 21–26.

*PEISSEL, R. 1925. Bau und Entwicklungsgeschichte von *Fimbriaria blumeana*. Bot. Archiv. 10: 434–76.

SRINIVASAN, K. S. 1939. On the developmental morphology of androgynous receptacles in *Marchantia palmata* Nees. Proc. Indian Acad. Sci. 10B: 88–97.

*TAYLOR, TH. 1834. De Marchantieis. Trans. Linn. Soc. 17: 375–95.

TOWNSEND, A. A. 1889. An hermaphrodite Gametophore in *Preissia commutata*. Bot. Gaz. 28: 360–62.

* Original publication was not seen.

# THE ANATOMY OF THE FLOATS OF
## *UTRICULARIA FLEXUOSA* VAHL.

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(Received for publication on April 8, 1953)

THE presence of floats, which are swollen and spongy structures, constitutes a characteristic feature of the inflorescence in *Utricularia stellaris*. In *U. flexuosa*, on the other hand, they are usually not known to occur. In exceptional cases, however, they are seen on plants belonging to this species as well. When they are present, they are much larger than those of *U. stellaris*, being 20 mm. in length and 4 mm. in diameter, while those of *U. stellaris* are only 8 mm. long and 3·5 mm. in diameter. They are branched at the tip and the branches are further divided into fine capillary segments. Their number may vary from one to half a dozen on one inflorescence and they are irregular in arrangement.

Fig. 1 shows the main body of the float in transverse section. This has a circular outline. The epidermis is studded here and there with glandular hairs. The stalk of the hair is short and consists of only two cells, a long basal and a short upper cell (Figs. 2–5). The gland consists either of two cells only which are very much elongated (Fig. 3), or of several cells some of which become larger than others (Figs. 4 and 5). The cortex contains many air chambers which are arranged more or less in a ring and constitute the main bulk of the float. On the outer side they are limited directly by the epidermis; only in certain regions a layer of cells may be present on the inner side of the epidermis. The chambers are separated from one another laterally by partitions which are mostly only one cell thick. On the inner side the chambers extend almost to the centre, leaving a very small space for the stele and pith. Only two layers of cells, which are parenchymatous, intervene between the chambers and the stele. The endodermis could not be recognized and there was no indication of the presence of a sclerenchymatous pericycle.

The vascular bundles are essentially arranged in a ring. The noteworthy feature of the bundles is the dissociation of xylem and phloem from each other at various levels. Consequently, a transverse section shows the two tissues forming separate bundles in addition to others

FIGS. 1–7. *Utricularia flexuosa*.—Fig. 1. T. S. of the float, × 71. Fig. 2. Three-celled stage of glandular hair, × 340. Fig. 3. Hair with gland consisting of two elongated cells, × 340. Figs. 4 and 5. Hair with gland consisting of several cells, some of which become larger than others. Fig. 4, × 340. Fig. 5, × 366. Fig. 6. T. S. of the stelar region of float, showing dissociation of xylem and phloem in most bundles, × 523. Fig. 7. Portion of the T. S. of the stelar region showing phloem-like cells on the inner side of the xylem vessels, × 523.
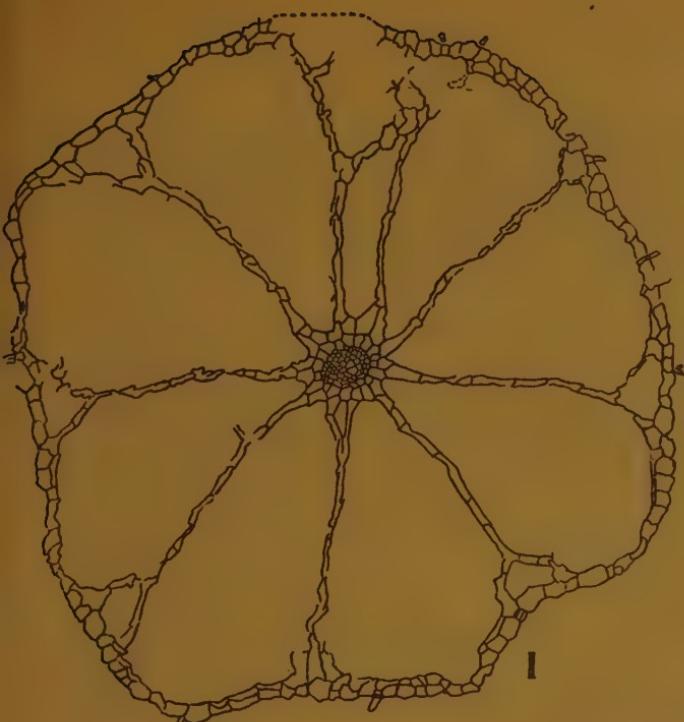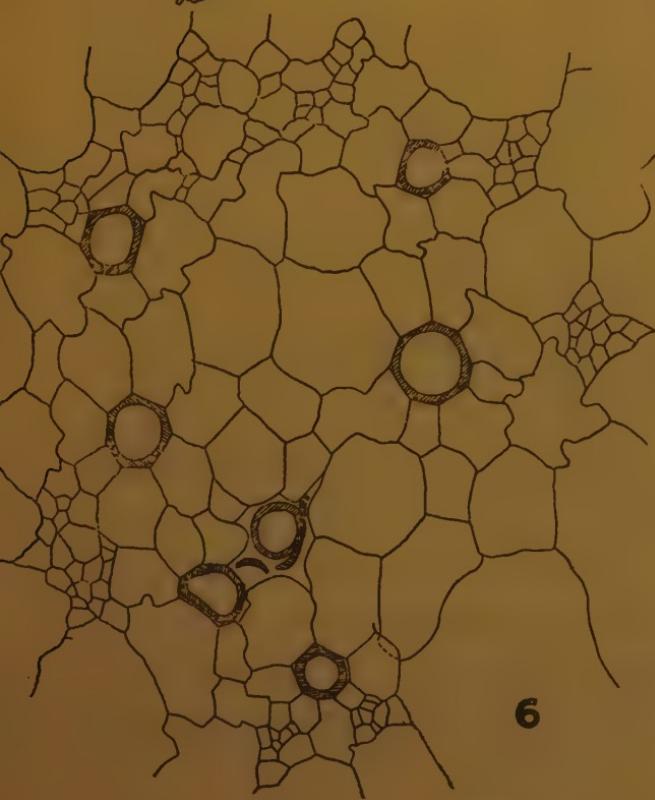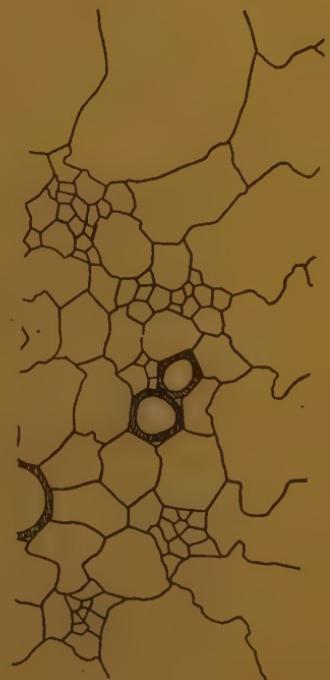
FIGS. 1-7

which show the usual conjoint condition (Fig. 6). Even after dissociation the phloem is seen in the peripheral region and the xylem towards the centre (Fig. 6), although in one case a few phloem-like cells were seen on the inner side of the xylem cells as well (Fig. 7). The conducting elements are very much reduced and the cambium is absent. These features, together with the presence of air chambers, seem to be associated with aquatic habit.

As we pass to the branches of the floats, the vascular elements, pith and the air chambers of the cortex go on diminishing. Eventually the entire stele is represented by a single xylem cell associated with a few phloem-like cells occupying the central region. This is surrounded by only two layers of cells, the outer of which is the epidermis.

The dissociation of the xylem and phloem has been described by earlier workers in the stem of *Polypompholyx* (Lang, 1901), *Genlisea* (*see* Solereder, 1908), and *Utricularia* (Schenk, 1887 and Merz, 1897). It seems, however, that the floats have not been studied so far from this point of view. There is also some controversy regarding the morphological nature of the floats. Haines (1922), Rendle (1925) and Lloyd (1942) regard them as leaves. Arber (1920), on the other hand, has discussed them under the heading of shoots. Barnhart (1916) regards them as modified scales. They show no trace of dorsiventrality and the stele is typically that of a stem. It is interesting to note in this connection that McIntyre and Chrysler (1943) regard even the leaf-like photosynthetic organs of *Orchyllium endresii* as specialized branches or cladodes on the basis of their anatomical study.

I am grateful to Dr. Reayat Khan who gave me the material and helped me in writing the account. I am thankful to Dr. P. Maheshwari for consulting some literature belonging to him.

## LITERATURE CITED

ARBER, AGNES. 1920. Water Plants. Cambridge.

BARNHART, J. H. 1916. Segregation of Genera in Lentibulariaceæ. Mem. New York Bot. Gard. 6 : 39–64.

HAINES, H. H. 1922. The Botany of Bihar and Orissa. London.

LANG, F. X. 1901. Untersuchungen über Morphologie, Anatomie und Samenentwicklung von *Polypompholyx* und *Byblis gigantea*. Flora 88 : 149–206 (cited from Solereder, 1908).

LLOYD, F. E. 1942. Carnivorous Plants. Waltham.

McINTYRE, W. G. AND CHRYSLER, M. A. 1943. The morphological nature of the photosynthetic organs of *Orchyllium endresii*, as indicated by their vascular structure. Bull. Torr. Bot. Club, 70 : 252–60.

MERZ, M. 1897. Untersuchungen über die Samenentwicklung der Utricularien. Flora 84 : 69–87 (cited from Solereder, 1908).

METCALF, C. R. AND CHALK, L. 1950. Anatomy of Dicotyledons. Vol. II. Oxford.

RENDLE, A. B. 1925. The Classification of Flowering Plants. Vol. II. Dicotyledons. Cambridge.

SCHENK, H. 1887. Beiträge zum Kenntnis der Utricularien. Jahrb. Wiss. Bot. 18 : 218-35 (cited from Solereder, 1908).

SOLEREDER, H. 1908. Systematic anatomy of Dicotyledons. Vols. I and II. Oxford.

# NOTES ON *CYCAS* PLANTS GROWING
# AT ALLAHABAD

By Divya Darshan Pant

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*Cycas revoluta* is a common ornamental plant in the gardens at
Allahabad and plants of *C. circinalis* and *C. rumphii* are also seen grow-
ing at some places.   Although no species of the genus is native of the

## CORRIGENDA

### (Vol. XXXII, No. 3)

Page 145, *add* at the end of 1st para: Only female plants have been
   observed.
Page 146, Fig. 1, *label* the three horizontal lines, I, II and III
   from the top downwards.
Page 147, line 10, *for* Leaves *read* Leaf.
Page 147, Fig. 2, *for* ×ca. 1/3 *read* ×ca. 1/6.
Page 148, Fig. 3, *for* ×1,700 *read* ×850.
Page 149, Fig. 4, *for* ×ca. 1/2 *read* ×ca. 1/4.
Page 149, Fig. 5, *for* ×ca. 2/3 *read* ×ca. 1/3.
Page 151, Fig. 7, *for* ×1 *read* ×1/2.
Page 152, Fig. 8, *for* ×ca. 2/3 *read* ×ca. 1/3.
Page 153, Fig. 10, *for* ×1 *read* ×1/2.
Page 154, line 20, *for* divelopment *read* development.
Page 154, line 24, *add* with additional pinnæ *after* *C. revoluta*.
Page 154, line 46, *for* megasporangia *read* sporangia.
Page 156, line 7, *for* London *read* Cambridge.
Page 156, line 24, *add* Vol. I *after* Plants.

year with scale leaves intervening every time between any two crowns.
Before the sudden growth of fronds or megasporophylls the apices
of the preceding young scale leaves are spirally twisted like the cords
of a rope, securely protecting and completely hiding the underlying
apex and other growing structures.

## DURATION OF CROWNS

Again, according to Coulter and Chamberlain (*loc. cit.*) the "information in regard to the duration of the crowns (in *Cycas revoluta*) is scanty and uncertain". However, in the locally growing plants of *C. rumphii* and *C. circinalis* two or three earlier crowns may be seen below the latest leaves while *C. revoluta* plants may not uncommonly exhibit unabscissed leaves of four or five successive generations (see Fig. 1). In a plant of the last mentioned species, below a freshly developing light green crown of erect soft young leaves, can be seen the
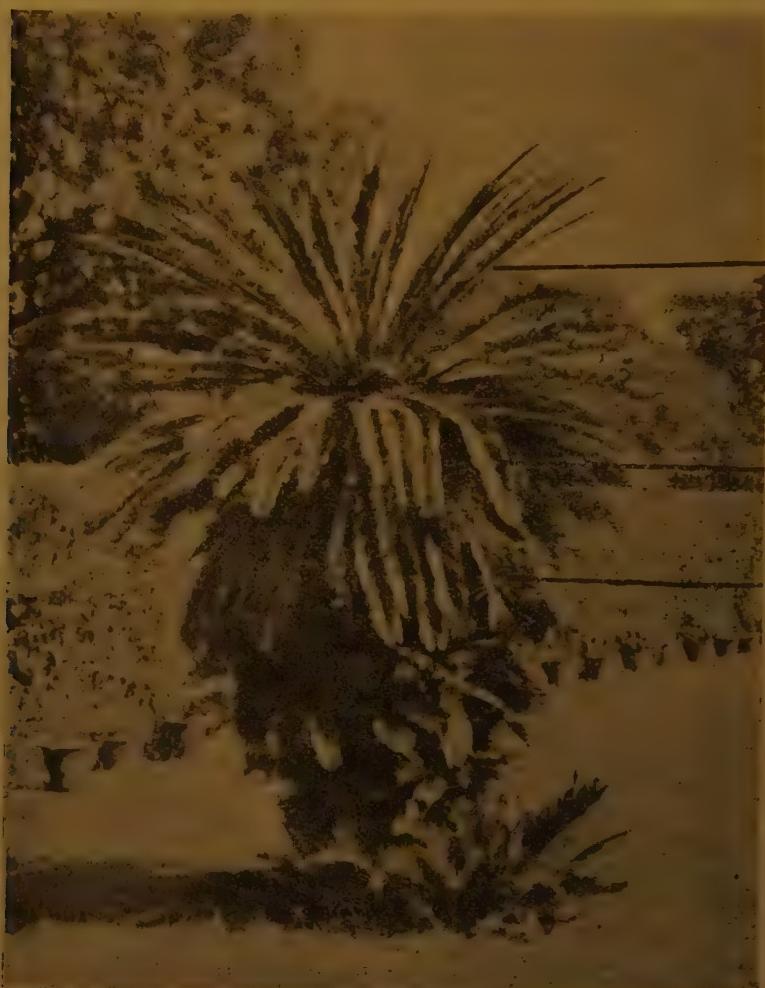


FIG. 1. A tree of *Cycas revoluta* just before the emergence of a new crown. Three crowns can be easily recognised in the Photo (I, II and III), a fourth and still older crown is completely hidden from view by the third (III) crown, ×ca. 1/20.

obliquely standing tough and leathery dark green leaves of the preceding crown followed by an earlier generation whose leaves become horizontal. Under them may be seen a still older crown of downwardly bent leaves whose apices become upcurved and sometimes even below this may be present the completely reversed and more or less dried up and withered fronds and rachises of a fifth generation, lying almost parallel and appressed to the tree trunk—these leaves are almost completely hidden from view by the obliquely reflexed fronds of the subsequent crowns.

### VERNATION OF THE RACHIS OF YOUNG LEAVES

Although there is complete unanimity among various authors regarding the obvious circinate vernation of the young leaflets, there are conflicting reports about the vernation of the young rachises. Rendle (1904), Wieland (1906), Seward (1917) and Pilger (1926) mention that the developing rachis in the genus is straight while Coulter and Chamberlain (1921) and Chamberlain (1935) and others have stated that the " vernation is circinate in the midrib and the pinnules of *Cycas*". The author has, however, constantly observed that although the entire proximal part of the rachis is straight, its apex is distinctly incurved (Fig. 2) in all the three species of the genus growing at Allahabad.



FIG. 2. A newly developed crown of leaves of *C. revoluta*. The pinnæ are circinately coiled and the rachises are incurved at the tip,  ×ca. 1/3.

## PITS IN OUTER WALLS OF EPIDERMAL CELLS

A unique anatomical feature noticed while examining some sections of the leaflets of *C. revoluta* is the presence of rows of pits on the outer walls of the epidermal cells. It is, of course, well known that simple pits occur in the cell walls of mesophyll and in the radial and inner walls of epidermal cells of *Cycas* pinnæ (Haberlandt, 1914, p. 264) but in the epidermal cells of the pinnæ and rachis of *C. revoluta* there are abundant simple pits (which may appear to be narrowly bordered) on all the walls. These pits are generally oval in outline and arranged in longitudinal rows on the outer walls of the ordinary epidermal cells and the numerous encircling cells of the stomata (Fig. 3). All these pits, however, appear to be occluded by the thick cuticle and their function is therefore difficult to understand.



FIG. 3. A stoma of *C. revoluta* showing pits on the walls of the encircling cells (*en*) and epidermal cells (*ep*). *g*—guard cell, *s*—subsidiary cell, ×1,700.

Pits are also present in the outer walls of the epidermal cells of *C. rumphii* and *C. circinalis* pinnæ, but in these species they are neither so frequent nor so clearly marked.

## ABNORMAL "V" OR "Y"-SHAPED PINNÆ

Two types of abnormal pinnæ are commonly seen in the leaves of local plants of *C. revoluta*. One of these consists of pairs of adjacent pinnæ which are often seen arising very close to each other usually towards the basal side (*i.e.*, immediately above the region of the spines on the rachis) of the first few leaves in young bulbils of *C. revoluta*. Some of these pairs are V-shaped (Fig. 4) having a common lamina at the base, but often their two veins are distinct from the very beginning. Sometimes, a preceding spine may seem to imitate the process and appear to be double (perhaps like the spines in leaves of

*Encephalartos villosus* (see Schuster, 1932, p. 26, Fig. 6, B), a fact which obviously confirms their homologous nature with that of the pinnæ. Besides these, occasionally there may also occur some dichotomously branched Y-shaped pinnæ in which a single midrib enters the base of



FIGS. 4 AND 5. The earliest vegetative leaves in bulbils of *C. revoluta* showing V and Y-shaped pinnæ and pinnæ with "laminiform spines". The petiolar spines also appear to imitate the feature.

the leaflet and thereafter forks into two (Figs. 5 and 6). But whether they are V-shaped or Y-shaped the two forks of such pinnæ are always unequal, the basal branch being more or less smaller. In some pinnæ it seems that the basal branch is so small that it is represented only by a small spinous serration on the lower margin, and a vein terminates therein. Similar unequally forked pinnæ also occur in *Encephalartos Lehmanni* and "*E. caffer* (?)" (Wieland, 1906, p. 212 and Fig. 123, C and D), although the pinnæ of *E. horridus* (Wieland, *loc. cit.*) are simple with only laminiform spines on the lower margin of the lamina.* According to Wieland (*loc. cit*) the forked pinnæ of the former species are due "to the development of a lower basal spine into a broad lamina thus forming an unequal dichotomy of the blade". On the other hand if the theory of recapitulation be applied here the occurrence of forked Y-shaped pinnæ in the first few leaves of young bulbils and their usual absence in later leaves of *C. revoluta* would suggest that forked leaflets may be ancestral and it is quite possible that simple spinous pinnæ like those of *E. horridus* are reduced structures, their spines representing suppressed lobes of a dichotomously branched

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* Schuster (1932) on the other hand has figured forked pinnae in *E. horridus* (p. 30, fig. 8, B) and simple pinnae with laminiform spines on both sides in *E. septentrionalis* (p. 32, fig. 9, O).
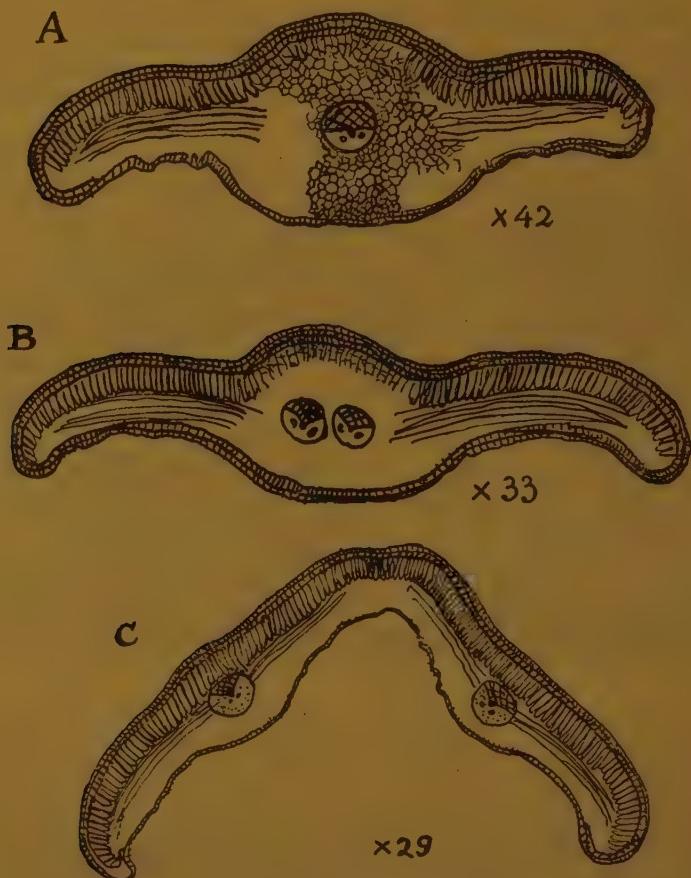
FIG. 6. Transverse sections of a Y-shaped leaflet.    Section A shows a single "mid rib" bundle.   In B the "mid rib" has two bundles while D passes through the region where the lamina is about to fork forming the two arms of the Y (Semidia-grammatic).

leaflet.  Similarly forked or closely arising pinnate lobes are also very often found in the sterile apical part of the megasporophylls of *C. revoluta* (see Fig. 7).

### ADDITIONAL PINNÆ IN ABNORMAL LEAVES OF *C. revoluta*

Another interesting and hitherto unaccounted abnormality is so frequently seen in the older horizontal or downwardly reflexed fronds of some of the local adult trees of the same species (*C. revoluta*) that it could almost be regarded as a normal feature.  On their adaxial side near or some distance behind the apex of their rachises, usually at the bend of the upcurved apical portion, can be seen some much smaller accessory pinnæ which are arranged in two additional adaxial rows, each row having at the most six, but usually less than six, leaflets

Fig. 7. Megasporophyll of *C. revoluta* showing closely arising and forked pinnate lobes in the sterile end part,   ×1.

on either side of the rachis  just above  the normal rows (see Fig. 8). These additional pinnæ are at first absent but develop later in the mature leaves.   Their growth and formation are under observation and will be reported in due course.

The form and the internal structure of these additional pinnæ are the same as those of the normal ones and  each one of them receives a single vein ("mid-rib") which arises as a branch from one of the bundles of the rachis in the region of their insertion.   Often, like the apical structure at the end of the two normal rows, a terminal leaflet or spine-like process is placed almost medianly at the end of these two additional rows also.

When viewed from above these additional pinnæ appear to have a peculiar inverted insertion, with their dorsal or lower sides adaxial and their ventral sides facing those of the normal leaflets.   On the other hand, if we compare the four ranked arrangement of the normal and the abnormal pinnæ and their orientation in this part of the rachis with that of leaves on a dorsiventral stem like that of *Selaginella*, the rachis manifests a strange resemblance with such a stem.   In fact the "dorsiventral, frond-like, anisophyllous," unbranched fossil stems of *Tingia* (see Browne, 1933 and *cf.* Fig. 9), a genus of uncertain affinities which was at one time actually referred to the  cycads, form a much closer parallel.  In the present case the ventral or upper sides of all pinnæ will appear to be all turned towards  the apex of the rachis (like

FIG. 8.　Apical part of a leaf of *C. revoluta* showing adaxial accessory pinnæ. No. 1 is the median terminal pinna while Nos. 2 to 7 are arranged in two additional rows, ×ca. 2/3.
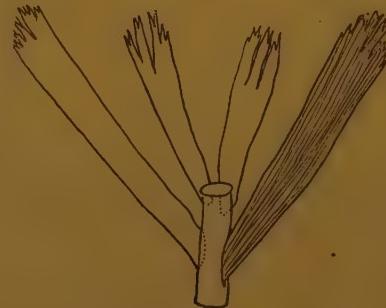


FIG. 9.　Reconstruction of a part of the frond-like axis of *Tingia* (*after Lady Isabel Browne*).

the apex facing upper sides of the leaves on a stem), although in the case of *Cycas* the dorsiventrality of the frond has more or less deflected them from their normal posture.

The fronds of *Cycas* simulate stems in other ways also. It is a well-known fact that in other species of the genus (especially in *C. rumphii* and *C. circinalis*) the strong midribs of the pinnæ in the terminal part of the leaves, when seen from the lower side, actually look like a series of monopodial branches from the rachis which tend

to be truly dichotomous towards its apex. The fronds of *C. micho-litzii* (Schuster, 1932, p. 28, Fig. 7, B) or *Macrozamia heteromera* (Schuster, *loc. cit.*, p. 32, Fig. 9, N) go a step further—even their pinnæ are repeatedly and deeply forked. Similarly dichotomised "concresc-ent" pinnæ sometimes occur in *C. circinalis* (Seward, 1917, pp. 13 and 14 and Schuster, 1932, p. 28, Fig. 7, A) and as reported in these notes quite frequently in the bulbils of *C. revoluta*. These dichotomies of the exterior, in fact, appear to be seated deeper; according to Matte (1904, Pl. I, Figs. 1–4 and 8–11) the rachis of *Cycas* contains within it a dichotomously branching system of bundles, the ultimate free ends of which enter the pinnæ.

### ABNORMAL MEGASPOROPHYLLS

The megasporophylls of *Cycas* are, as ordinarily described, leaf-like structures with lateral pinnately arranged sterile lobes and ovules but in the megasporophylls of *C. rumphii*, I have very often noticed ovules which are instead of being inserted in two lateral rows, attached in two rows on each side or otherwise arranged side by side dorsiventrally on either side of the megasporophyll (Fig. 10).



FIG. 10.   Megasporophyll of *C. rumphii* showing the lower ovules arranged in two rows on either side,   ×1.

The homologous nature of the fronds and the megasporophylls of *Cycas* is thus supported even by the occurrence of similar aberrations in the two types of structures (paired and forked pinnæ and dorsiventrally arranged pinnæ and ovules) but besides this the abnormalities and other facts enumerated above support their fundamentally axial nature also.

The leaf of the Pteropsida (Megaphyllous Trachæophyta) has been interpreted as a modified branch system (Prantl, 1875, Potonie, 1899 and Tansley, 1908—see Bower, 1935, p. 550). The *Cladode Megaphyll Theory* of Bower (*loc. cit.*, pp. 550–52) and the *Telome Theory* of Zimmermann (1930) suggest essentially the same thing; the latter even including the microphyll in the same generalisation. Recently Arber (1950, pp. 70–123) has suggested that the leaf should be regarded as a "partial shoot" with an "urge towards the attainment of whole-shoot-hood". Arber's *Partial Shoot Theory* is in fact not in any way contradictory but complementary to these earlier theories. Amongst other arguments in support of her hypothesis, she has quoted instances of *Brassica oleracea* and *Platanus acerifolia* leaves (Arber, *loc. cit*, pp.110 and 111, Fig. 15, A 1, A 2, B 1 and B 3) where the midribs show a "genuinely shoot-like divelopment". In addition, the author has very frequently observed similar shoot-like development in the leaves of young vigorous female plants of *Carica papaya* (the abnormality is much less frequently seen in male plants)—see Fig. 11. The present leaves of *C. revoluta* may be regarded as further examples of the same tendency of the leaf towards the attainment of whole-shoot-hood. Interpreted on this basis, at least a female tree of *Cycas* with its monopodial columnar trunk and a crown of determinate partial shoots (fronds) assumes an aspect somewhat similar to that of an *Araucaria* tree with its indefinitely growing leader surrounded by whorls of pinnately branched secondary axes.

On the other hand, there could be other ways in which these additional pinnæ could be interpreted. For instance, they could be regarded as arranged on a branch of the rachis which may be assumed to have arisen by an unequal dichotomy but which was either unable to separate or which became fused with the other. The occurrence of bipinnate fronds in *Bowenia spectabilis* and of forked rachises in the leaves of some ferns and pteridosperms, *e.g.*, *Diplopteridium teilianum* (Walton, 1931) lends colour to these ideas.

It seems, however, that whatever be the ultimate nature of the various parts involved, the *Telome Theory* can best explain all the points in a very fundamental way. Both the external dichotomies and the usually forked vascular bundles of the rachis suggest an organ which has undergone overtopping, planation, webbing and fusion like what has been pointed out for the axes of *Medullosa heterostelica* by Stewart and Delevoryas (1952). The "Foliar" ovules of *Cycas*, in particular, could be regarded as terminal megasporangia on lateral branches of an axis system which has undergone overtopping and planation. The interpretation will also bring the fertile structures of the Cycadales in line with those of other gymnosperms, *e.g.*, the Coniferales and the

Fig. 11. Leaf of *Carica papaya* showing "tendency towards the attainment of whole shoot-hood" by forming leaf-like structures on the upper side (*l*), ×ca. 1/6.

Ginkgoales (see Wilson, 1953, p. 428–32). In the peltate megasporophylls of Cycadales other than *Cycas*, the megasporangia appear to have undergone recurvation in addition while the terminal megasporangia of *Cycas* are erect and orthotropous.

## SUMMARY

In adult plants of three species of *Cycas* growing at Allahabad foliage leaf crowns are usually formed twice a year (the production of crowns in young plants is irregular). The crowns frequently last for more than an year. The raches of young leaves in all the three species are incurved at the apex. Simple pits occur in the outer walls of epidermal cells of the pinnæ. In *C. revoluta* V-and Y- shaped pinnæ are

frequently found in the first few leaves of young bulbils and mega-
sporophylls and additional abnormal pinnæ are formed in the adult
leaves of fully grown plants. The structure of these abnormal pinnæ
and their theoretical significance are briefly discussed. In *C. rumphii*
ovules are found attached in more than two rows.

## LITERATURE CITED

1. ARBER, A. 1950. The Natural Philosophy of Plant Form. London.
2. BOWER, F. O. 1935. Primitive Land Plants. London.
3. BROWNE, I. 1933. The Noeggerathiæ and Tingiæ. The effect of their recognition upon the classification of the Pteridophyta : an essay and a review. New Phytol. 32 : 344–58.
4. CHAMBERLAIN, C. J. 1935. Gymnosperms, structure and evolution. Chicago.
5. COULTER, J. M. AND CHAMBERLAIN, C. J. 1921. Morphology of gymnosperms. Chicago.
6. HABERLANDT, G. 1914. Physiological Plant Anatomy. London.
7. KASHYAP, S. R. 1921. Some observations on *Cycas revoluta* and *C. circinalis* growing at Lahore. Jour. Ind. bot. Soc. 2 : 116–22.
8. MATTE, H. 1904. Recherches sur l' appareil libero-ligneux des Cycadacees. Théses présentèes a la facultè des sciences de l' Université de Caen.
9. McLEAN, R. C. AND IVIMEY-COOK, W. R. 1951. Text-Book of Theoretical Botany. Vol. I. London.
10. PILGER, R. 1926. Cycadales. In Engler und Prantl, Die Naturlichen Pflanzenfamilien. Bd. 13. Leipzig.
11. RENDLE, A. B. 1904. The Classification of Flowering Plants. Cambridge.
12. SCHUSTER, J. 1932. Cycadaceæ in Das Pflanzenreich. Leipzig.
13. SEWARD, A. C. 1917. Fossil Plants, III. Cambridge.
14. STEWART, W. AND DELEVORYAS, T. 1952. Bases for determining the relationships among the Medullosaceæ. Amer. Jour. Bot., 39 : 505–16.
15. WALTON, J. 1931. Contributions to the knowledge of the Lower Carboniferous plants. Part III. Phil. Trans. Roy. Soc. London. B, 219 : 347–79.
16. WIELAND, G. R. 1906. American Fossil Cycads. Vol. I. Carnegie Institution of Washington Publication.
17. WILSON, C. L. 1953. The telome theory. Bot. Rev., 19 : 417–37.
18. ZIMMERMAN, W. 1930. Die Phylogenie der Pflanzen. Jena.

# REVIEW

**Flora of the British Isles.** By A. R. CLAPHAM, T. G. TUTIN and
E. F. WARBURG. Cambridge University Press, 1952. Pp. Li+1591.
Price 50 *s*.

This is an up-to-date account of the British vascular plants and
takes into full consideration the advances in the field of taxonomy
during the last 50 years, and especially since 1920. The introduced
plants, both naturalised as well as of frequent occurrence, are included.
Besides the usual descriptions, information is given in many cases
about the time of flowering, fruiting and germination of seeds, the
mechanism of pollination and seed dispersal as well as the life form
and chromosome number.

The families are arranged with minor exceptions according to the
system of Bentham and Hooker. The account begins with the Pterido-
phyta. This is followed by Gymnosperms and Dicotyledons and ends
with the Monocotyledons. An artificial key to the families has been
added, which permits their identification even by an amateur.

The nomenclature follows in general the check list of British
Vascular Plants issued by the British Ecological Society in 1946. The
small initial letter has been adopted for all specific epithets.

Plants which are morphologically similar but differ cytologically
or in geographical distribution or ecological habitat have been de-
scribed as subspecies. Authenticated hybrids between species have
been mentioned. Another special feature of the book is the inclusion
of references to easily accessible illustrations.

Sometimes characters have been used for identification which
are not commonly considered. Two examples are the number, size
and distribution of the lenticels on the fruits in the Genus Sorbus
and sculpturing of the testa of seeds in Chenopodium.

After brilliant work by British and other European botanists in
the 19th century, taxonomic studies in India have been languishing for
various reasons, among which lack of a National Herbarium and good
regional herbaria are the most important. Most of our States are
still without good manuals of plants. This hampers progress in many
fields of botany. The need for the writing of up-to-date regional and
local floras, therefore, is very great. The present volume can serve
as a good example of what a modern Flora should be.

A. C. J.

Flora of the British Isles. By A. R. Clapham, T. G. Tutin and E. F. Warburg (Cambridge University press, 1952) Pp. i i-i i+1744. Price 50 s.